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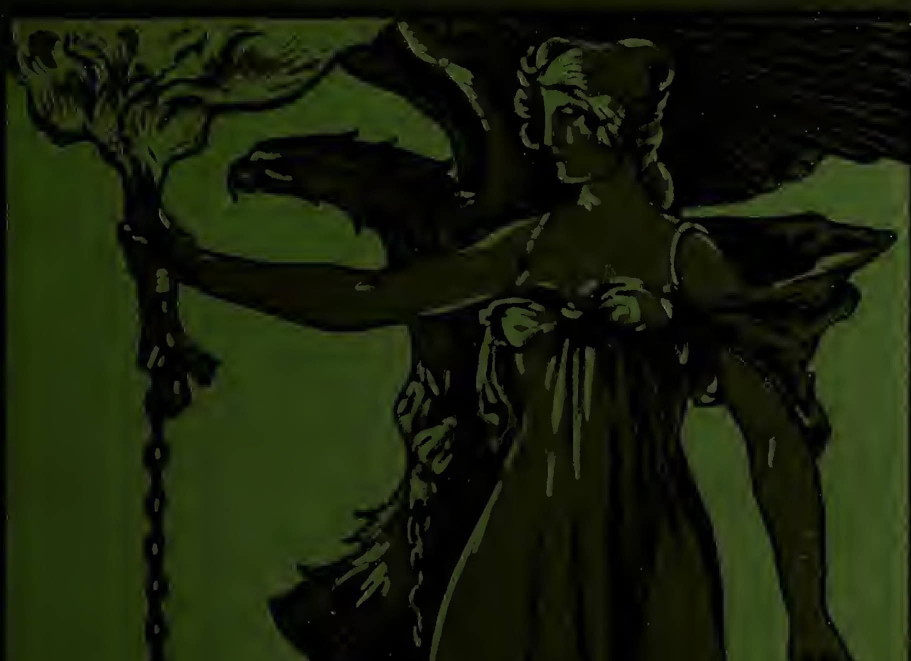

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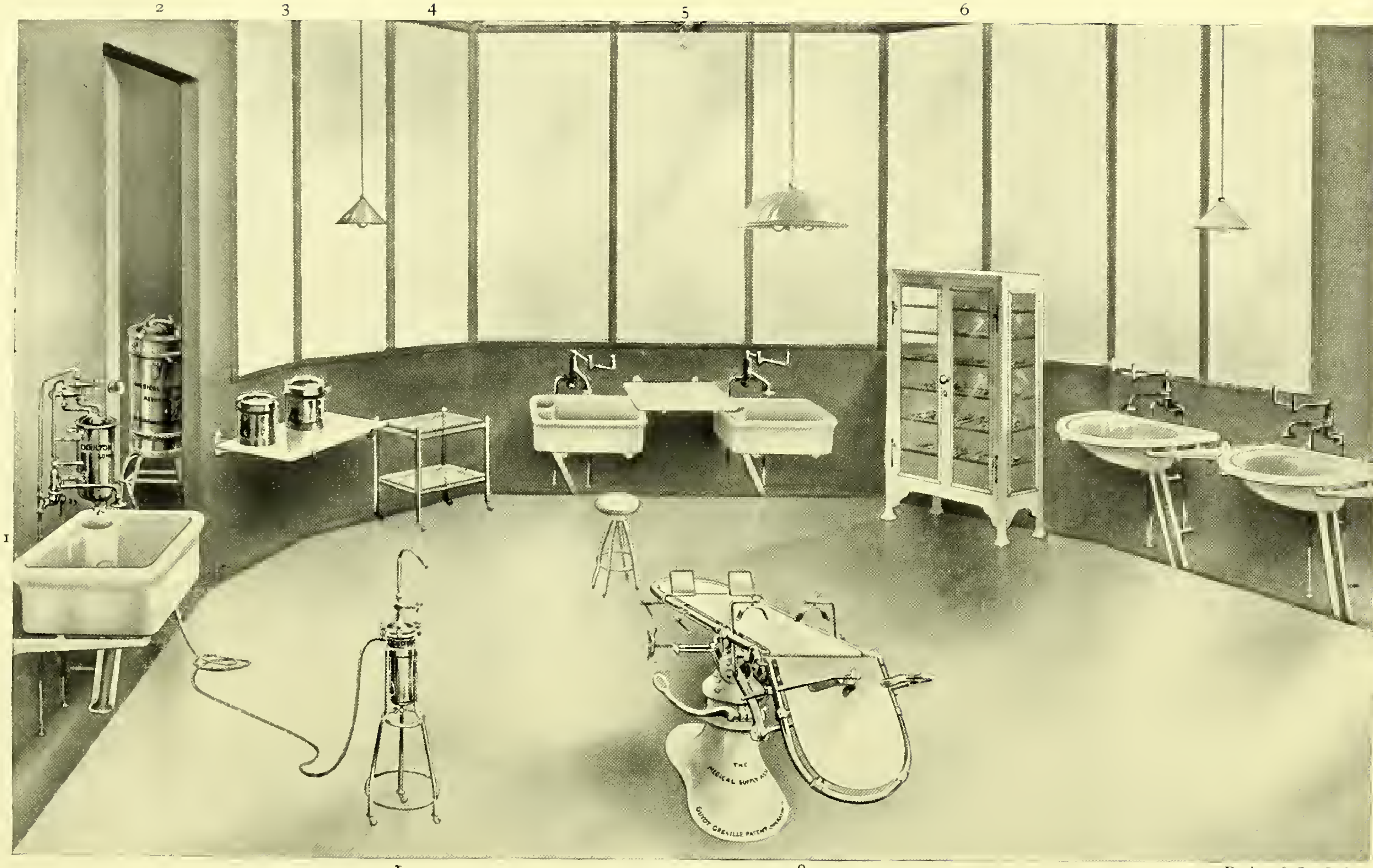

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A HOSPITAL OPERATING THEATRE

THE MODERN PLUMBER AND SANITARY ENGINEER

TREATING OF PLUMBING, SANITARY WORK, VENTILATION, HEATING (ELECTRIC AND OTHER), HOT-WATER SERVICES, GAS-FITTING, ELECTRIC LIGHTING, BELL-WORK, GLAZING, &c.

BY SIXTEEN SPECIALIST CONTRIBUTORS

UNDER THE EDITORSHIP OF

G. LISTER SUTCLIFFE

A.R.I.B.A., M.R.S.I.

Editor of "The Principles and Practice of Modern House Construction", &c.

WITH APPENDICES OF
TABLES, MEMORANDA, MENSURATION, ETC.

ILLUSTRATED BY ABOUT ELEVEN HUNDRED FIGURES IN THE TEXT AND ABOUT FIFTY PLATES, MANY OF THEM IN COLOUR

DIVISIONAL-VOL. IV

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CHAPTER IV

BATHS

The time is probably not far distant when a bath will be considered to be as necessary in every house, large or small, as a water closet or water tap is at the present moment. Indeed, it has already become a common practice, particularly in the Midlands and North Country districts, to introduce in the artisans' class of dwelling a fitting of this character—a practice that is worthy of emulation in other districts.

Position.—Under no circumstances should a bath be fixed in a bedroom, as, however carefully it is maintained, there is always a possibility of a sour or even offensive smell arising from the accumulation of soap curd and dirt in some part of the fitting. There is no great objection to a bath being placed in a dressing room; but where this is done, discretion is necessary to determine the description of fitting, as one with an enclosure is often selected so as to harmonize with the surroundings.

In private houses the bathroom ought not to be too far from the bedrooms. In hospitals and infirmaries the baths are usually fixed in a "sanitary block", separated from the wards by a ventilated lobby; but it is questionable whether isolation of these fittings is not sometimes carried to such extremes as to render a bath at least a doubtful pleasure, if not decidedly objectionable, owing to the exposure entailed.

Light and Ventilation.—The apartment should be well lighted and adequate means of ventilation provided, and, to be quite satisfactory, the floor and walls require to be constructed or lined with an impervious material, for which purpose substances ranging from Portland cement to expensive marbles are open to selection. Where this cannot be done in its entirety, a tiled dado around the back and ends of the bath, and the covering of the floor immediately under the bath with tiles, or a marble or slate floor-slab, are desirable.

Materials.—The materials used in the manufacture of baths include zinc, copper, steel, cast iron, and enamelled fireclay or porcelain.

Zinc baths are made, as a rule, of sheet zinc of Nos. 12 to 16 gauge, metallic-enamelled. Such baths are fragile and unsuited for hard wear. The material is not now in general use for plunge baths, but is still largely employed for shower enclosures, plate zinc taking the place of thin sheets.

Sheet copper, polished, tinned, or metallic-enamelled, is better than zinc, and is specially suitable for use in the construction of movable hospital plunge baths, as well as for hip and foot baths and for shower enclosures. Unless salt water is to be used in the bath, the copper should not be planished, as it is very difficult to keep clean. Metallic enamel is now most often used for both zinc and copper baths, but as it is easily chipped and scratched the baths soon require re-enamelling.

Another disadvantage of zinc and copper baths is the necessity, where thin metal is used, for support by means of a wooden cradle or casing, and as the use of wood in sanitary fittings is now generally tabooed, both

metals are now looked at with something approaching disfavour. If a cradle is required, it should take the form of an indurated wood casing, which has the advantage of a close grain and hard surface. For baths made of sheet copper of Nos. 12 to 16 gauge a cradle is not absolutely necessary, a large number now being made with a rolled edge and without a cradle. It is claimed that they are capable of withstanding a severe strain.

Baths made of **sheet steel** have of late come much into use for cheap work, and especially for tip-up baths for fixing in artisans' dwellings. The material is very strong, and, if galvanized, is fairly suitable for the purpose.

Sheet-metal baths are exceedingly useful where the quantity of hot water is limited, as the amount of heat absorbed is relatively small. For this reason they compare favourably with cast-iron or porcelain baths; the latter, in particular, absorb a large amount of heat, cooling the water so rapidly that, unless a plentiful supply is available, actual discomfort is caused to the bather.

Cast-iron baths have the great merit of cheapness combined with strength. The metal varies in thickness from $\frac{3}{16}$ to $\frac{3}{8}$ in., and the cheaper kinds are painted, japanned, or metallic-enamelled in one of three finishes—firsts, seconds, or thirds,—the relative distinctions being the thickness of the enamel and the finish of the surface, the most expensive being hand-polished. The metallic enamel is, however, quickly affected by common washing soda, and is somewhat difficult to keep clean. If the baths are galvanized or tinned, they are soon scratched, and oxidation then takes place. The best cast-iron baths are coated with porcelain or vitreous enamels, which are smooth, pleasing in appearance, and easy to keep clean. An enamel considerably harder than the ordinary porcelain has lately been used by one well-known firm, who claim that it is capable of resisting the action of acids. The enamel is, however, inclined to "flow", leaving the surface uneven.

Porcelain-enamelled fireclay baths have a smooth and clean appearance. They are, however, thick and heavy, and are difficult to obtain true in form, owing to warping during burning; they also absorb a large amount of heat. For public baths, where the fitting is in almost constant use and a plentiful supply of hot water is always available, they can be used with satisfactory results. For fixing without enclosures they can now be enamelled outside as well as in.

Marble baths are made by hollowing out a block of marble to the desired shape. They are very expensive, and have similar advantages and drawbacks to those made of porcelain.

Shape.—Plunge baths are commonly of two shapes, **parallel and taper**, as illustrated by figs. 502 and 503. The parallel bath is the more comfortable, but requires a larger quantity of water for its size than the taper bath. Generally both parallel and taper baths have a fall to the outlet at the foot; but the former are sometimes of the shape known as equal-ended, in which case the outlet is situated in the centre.

Size.—Baths vary from 5 to 7 ft. in length, 1 ft. 9 in. to 2 ft. 9 in. in

width at the widest or scoop end, 1 ft. 6 in. to 2 ft. 6 in. at the narrowest or square end, and 1 ft. 8 in. to 2 ft. 2 in. in depth. In baths 5 ft. only in length inside it is well-nigh impossible for a person of ordinary height to bathe comfortably. If possible, the size should, of course, be suited to the intended user; but for ordinary purposes a taper bath having inside mea-

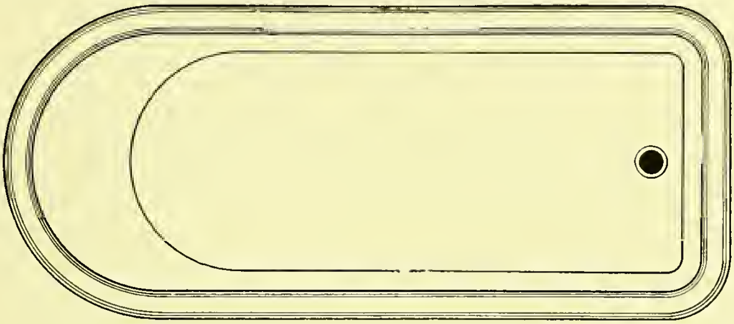


Fig. 502.—Parallel Bath with Roll Edge

surements of 5 ft. 6 in. in length, 2 ft. to 2 ft. 7 in. in width, and a depth over all of 2 ft. 1 in., will be most suitable.

Enclosed baths are rapidly being superseded by the Roman or open bath; but although the latter have come much into vogue, it is a moot point whether they should be indiscriminately recommended for all situations. The principle underlying their provision is that the whole surroundings are open for inspection and accessible for cleansing; but in many instances

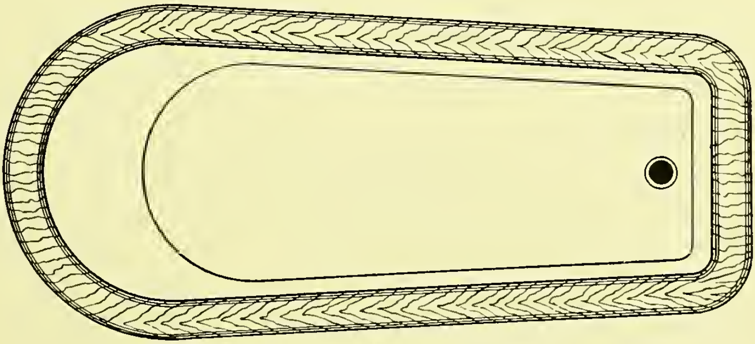


Fig. 503.—Taper Bath with Wood Rim

the bath is fixed in such a manner that it is impossible to obtain access to the back, in which case there is a greater risk of an accumulation of dirt than if a casing is provided. Baths ought to be fixed several inches away from the surrounding walls (fig. 504), and clear of the floor, so as to render it easy to cleanse the sides of the bath, the walls, and the floor.

Enclosed metal baths should have a flat rim or flange around, as shown in fig. 505, and the wooden top and sides should be carefully fitted, so as to exclude dust and dirt, the top being hinged, and the sides made so that they can be removed.

A rounded or roll edge is usually formed in the metal if the bath is to be fixed independently. The roll edge should be fairly broad and entirely free from sharp arrises, and may range in diameter from 2 to 4 in. Various patterns are illustrated in fig. 506. Movable baths for hospital or infirmary use are generally fitted with an anti-splash roll similar to No. 4.

Porcelain baths are made with **solid rolls** (fig. 507).

The modern equivalent of the wooden bath top is the **wood rim**, shown in figs. 503 and 504, which is screwed to the edge of the bath, and, being warmer and softer than metal or porcelain, is highly appreciated by invalids. Instead of a complete rim, a wood inset of the kind used for sinks is occasionally employed. Soap trays are frequently formed on baths beside the fittings.

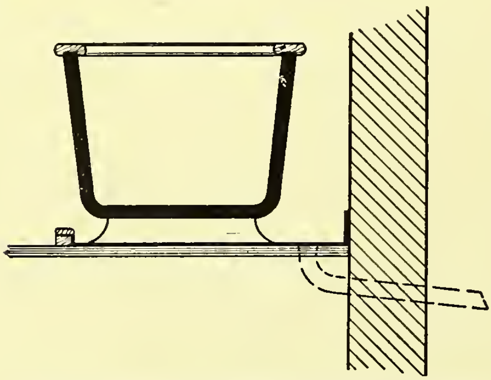


Fig. 504.—Fireclay Bath fixed clear of the Wall, and with Lead Safe under

Fig. 505.—Flange and Square Edge for Enclosed Baths

Safes.—Unenclosed baths are not often provided with safes, except perhaps under the fittings, as any water splashed over is in sight, and can be readily wiped up. For the best work a marble floor slab is a useful accessory. A waste pipe from this is not essential, but can be attached if desired. Occasionally safes are provided to porcelain baths, even when fixed without a casing.

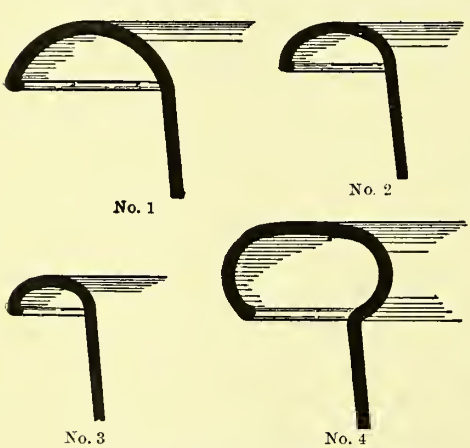


Fig. 506.—Roll Edges for Independent Baths

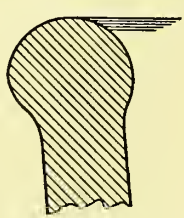


Fig. 507.—Solid Roll for Porcelain Bath

To form the safe[1], the floor under the bath should be covered with 5- or 6-lb. sheet lead, with a fall to the waste outlet, the corners being bossed and the lead made to stand up 3 to 4 in. against the skirting, and fastened with copper nails covered with a welt, or a wooden bead fixed and the lead

[1] See also Section III, Chapter XII.

worked over it. The exposed front and ends should be bossed over a wooden fillet about 1½ in. thick fixed to the floor, and the edge of the lead protected by a hardwood capping, as shown by fig. 504. An enclosed bath should have a similar safe, with the exception that the sides need not be fixed. The mistake is often made of fixing a waste pipe of too small a diameter, ¾ or 1 in. being used; whereas the minimum should be 1¼ in., and in some cases a 1½-in. or even 2-in. waste would not be too large, as the water supplied by the valves is under pressure.

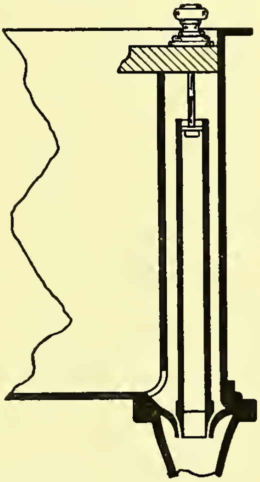


Fig. 508.—Enclosed Waste and Overflow

Waste holes in baths are generally placed at the foot, either in the bottom or in the angle formed by its junction with the end. In every case the sinking should be large enough to receive a brass or gun-metal washer with an enlarged inlet, having an internal diameter of 2 in. at the least if the outlet is to take the form of a solid plug or standing waste; the orifice should be protected only by a metal cross, so as not to impede the flow of the water.

The plug form of waste, which is the simplest and the one most frequently used, should be fitted with plugs made of woodite, vulcanite, indiarubber, or metal covered with indiarubber. Solid metal plugs of the size used for baths are heavy, and are liable to damage the enamel of iron baths and chip the surface of those made of porcelain.

The enclosed combined waste and overflow fitting (fig. 508) was at one time the usual form of a waste outlet, but, as in the case of lavatories, is now looked upon with suspicion, owing to its inaccessibility and foulness. Even the modernized form of hidden waste, which is made so as to be easily lifted out from its position, is not regarded with favour, as waste arrangements that are out of sight are usually neglected.

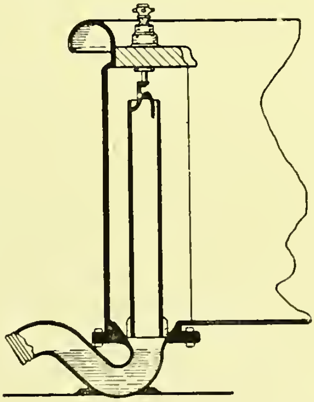


Fig. 509.—Exposed Waste and Overflow

Exposed lift-up combined waste and overflows have for good baths taken the place of the older variety, the waste being recessed at the foot of the bath, so as to be out of the way. There are many kinds, differing in detail, but all more or less similar to the type represented by fig. 509, which consists of a 2-in. copper tube having a spindle running through a guide plate. On being lifted up and given a slight turn, it is held clear of the waste orifice by a projection on the spindle, which rests upon the guide plate. The bottom end is fitted with an indiarubber seating. This kind of standing waste is detachable, and renders the use of a special overflow unnecessary.

The standing waste with siphonic overflow, illustrated in fig. 517, and

particularly referred to on page 200, has been fitted to baths, and is well adapted for the purpose, as the overflow is capable of carrying off a very large quantity of water.

Other kinds of waste apparatus which can be used for baths are illustrated in figs. 532 and 533.

Quick Wastes.—The provision of a small outlet is a mistaken policy, as it renders nugatory the otherwise useful, and in some cases indispensable, service which such a quantity of water discharged quickly into the drain is able to serve. To facilitate a speedy discharge, quick-waste outlets, with a 3-in. clearway orifice, are now made. An illustration of this type is given in fig. 510, where A is the outlet, B the connection with the waste pipe, and C the connection with the overflow.

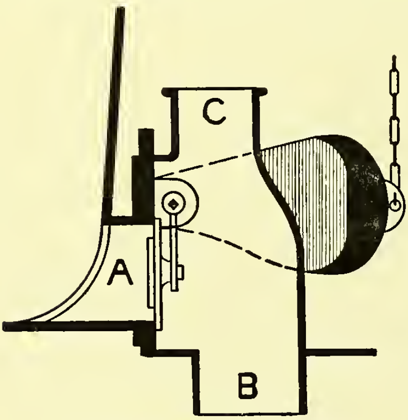


Fig. 510.—Quick Waste for Bath

Another serviceable waste apparatus for effecting the quick emptying of a bath is the horizontal valve, actuated by a spindle and lever, shown in fig. 514, which has been adapted for baths as well as lavatories. In this fitting the outlet and trap have a clear way of 2½ in.

Combined Inlets and Outlets.—Zinc and copper baths were often supplied with water through the waste outlet situated in the centre of the bath, as shown in fig. 511. The supplies of hot and cold water, as well as the waste, were connected to one common pipe, as indicated respectively by the letters A, B, and C, the valves being operated by spindles and levers attached to the bath top. The method is objectionable, as the incoming water washes back

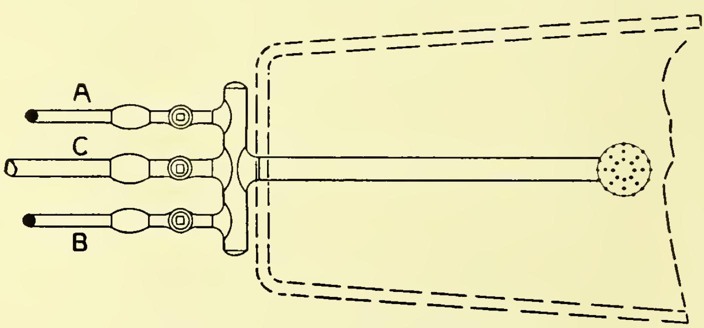


Fig. 511.—Combined Inlet and Outlet (Defective)

into the bath the dirty soap curds deposited in the waste pipe between the inlet and the plug cock when the bath was last emptied. Water companies also object to the arrangement, as a secret waste of water can take place.

Overflows.—In fireclay and iron baths where a standing waste is not provided, the overflow pipe is usually connected to the end of the bath about 3 in. below the top edge by means of a brass or gun-metal waste

outlet with grating and union. Sometimes for fireclay baths, instead of a metal connection being used, a lead collar is wiped on to the pipe, the end of which is passed through the overflow outlet and tafted into the sinking, a brass grating being fixed on the front, as shown at B, fig. 512. The use of a washer and union is to be preferred, as it allows for disconnection, and where this form of overflow is provided the grating covering the orifice should be hinged.

Overflows are frequently connected to the bath trap in a similar manner to the sink overflow illustrated in fig. 499.

Overflow as Warning Pipe.—Some water companies insist upon bath overflows being turned out through an external wall as a warning pipe. This can be done in the manner illustrated by dotted lines in fig. 512, or the waste pipe of the safe can be utilized as indicated in the same figure. If a considerable quantity of water is passed into the overflow, the ground on to which the water is discharged is likely to be made offensive, and it is, therefore, hardly a good arrangement to treat it altogether as a warning pipe, which is only expected to come into use at rare intervals. Another disadvantage of discharging the overflow direct into the external air is the fact that it permits a current of air to pass through the pipe into the bath, which in cold weather is unpleasant. To obviate this, a copper flap valve is sometimes provided on the outer end, but this is apt to become fixed, rendering the overflow useless.

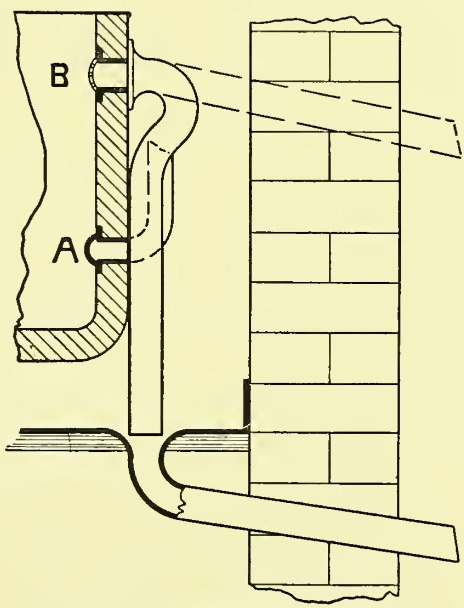


Fig. 512.—Overflow as Warning Pipe

Open Overflows.—Similarly to sinks and lavatories, cast-iron baths are made with an open overflow, which forms a part of the casting and discharges under the outlet grating, but above the water in the trap. This form of overflow is adopted in the bath shown in fig. 514, which is an excellent fitting, embodying not only an accessible overflow and quick-waste arrangement, but also the latest ideas in bath-construction. As will be seen, the ledge to which the valves are attached is sloped, and the bottom has a sharp fall to the outlet. Whatever the form of overflow, the inlet to it should be accessible for cleansing, and the open type shown in fig. 514 is therefore superior to that illustrated in fig. 508. The quick waste shown in fig. 510 is arranged to receive the overflow above the level of the standing water in the trap at C.

Although in the opinion of many sanitarians these methods are superior in practice to the warning pipe, they are open to the objection common to

all fixed pipes, *i.e.* the difficulty of access or removal for cleansing, and the consequent liability of offence from the accumulation of soapy matters in the pipe. Owing to its accessibility an exposed overflow of the standing-waste type must be considered as open to the least objection.

The remarks on the size of safe-waste pipes apply with equal force to overflows.

Traps used for baths are usually of iron, brass, gun metal, or lead. With the cheaper kinds of cast-iron baths, iron or brass traps of the lip type are commonly supplied. The shape is bad, and the casting is as a rule very rough. Sometimes they are porcelain- or glass-enamelled, but even then they cannot, owing to their shape, be recommended as a good fitting. The brass or gun-metal trap, tubular in shape, is better. For exposed positions these are polished, nickel-plated, or porcelain-enamelled, and they possess the advantage of occupying a small amount of space, which is of moment, as it is frequently necessary to fix the trap above the floor. Where such traps are employed, they should always be vitreous-enamelled inside. Where the space admits of a lead trap, there need be no hesitation in saying that for general use it is preferable.

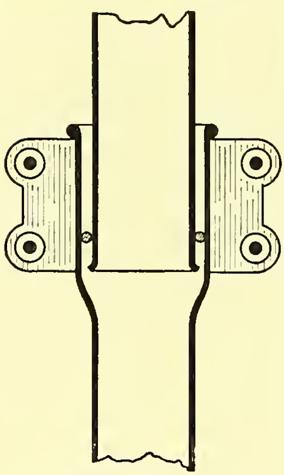


Fig. 513.—Expansion Joint

Waste Pipes.—If the waste pipe is to be fixed inside the premises, it should be of screwed wrought iron, or heavy cast iron, the joints of the latter being caulked with metallic lead, and the pipes vitreous-enamelled inside, and coated with a suitable solution outside. Considered generally, the best material for waste pipes is lead, but as the discharge of hot water through the pipes makes it unwise to use wiped joints, these pipes should be reserved for positions outside the external walls. Even if heavy lead pipes weighing 12 to 14 lb. to the foot are used, their rigidity, when fixed and connected with wiped joints, tends—under the influence of rapid changes of temperature—to twisting and breaking.

For lead waste pipes intended to receive hot water, **expansion joints** (fig. 513) should be used at intervals not exceeding 6 ft., the pipe being fixed to the wall with lead tacks. Where the use of lead pipe with wiped joints is insisted upon, it would be better to use the pipe brackets illustrated in fig. 582, but even this mode of fixing is inferior to expansion joints.

Connection and Disconnection of Waste Pipes.—Under no circumstances should a bath waste be connected to a soil or any other pipe used for conveying fæcal matter or urine, owing to the risk entailed in the event of the pipe becoming fractured. Nor is it the best practice to turn the bath waste out through the external wall into a hopper head. The waste pipes attached to baths in public institutions are sometimes made to discharge into an open channel emptying over a gully, but this practice should only be followed where constant attention is given to the cleansing;

for if the channel is neglected, nuisance will most likely ensue. All bath wastes should be disconnected from the drain and made to discharge into a disconnecting trap by a side or back inlet, so as to utilize the water to the fullest possible extent as a drain flusher. A special kind of trap to catch or dispose of the grease is not necessary for baths, as the quantity of soap in suspension is small compared with the large volume of water.

Ventilation of the trap and waste pipe is not absolutely essential in every case to assure the maintenance of the seal of a trap attached to an isolated

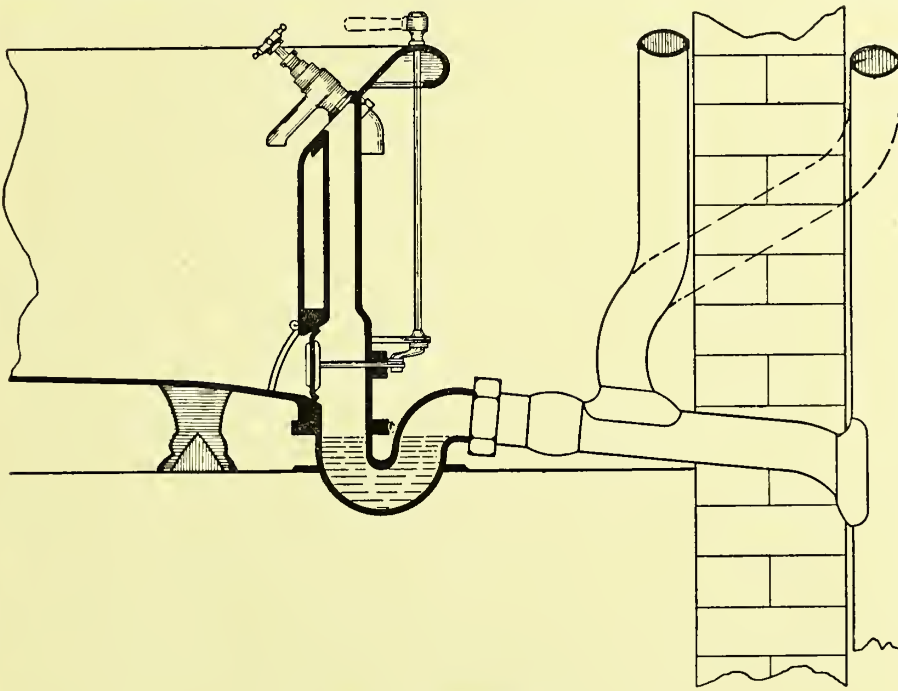


Fig. 514.—Waste and Trap-ventilating Pipes for Baths

bath, for although siphonage may occur during the emptying, there is generally a sufficient quantity of water draining out at the end of the discharge to make good any deficiency and prevent the trap from being permanently unsealed. But where the waste pipe is of considerable length, or where more fittings than one are attached, proper ventilation must be provided for.

For a single bath the waste may be treated in the same way as the sink waste shown in fig. 500, if the outlet can be placed in a position away from windows; but for a number of fittings the waste pipe should be carried up full size to a position affording a safe outlet for the foul air, and a trap-ventilating pipe fixed as illustrated in fig. 514. The trap vent pipe may be fixed inside the premises, until the highest fitting is passed, or may be turned out through the wall as shown by dotted lines, and carried up by the side of the main stack. Wiped joints should be employed for the

ventilating pipes, and the diameter of the latter be equal to the waste pipe. By disconnecting the bottom of the waste pipe and venting the top, a current of air can pass through the pipe, assisting to keep it in a sweet state.

Water Supply.—As previously mentioned, on no account should the waste outlet be used as the medium for the supply of clean water to the bath. The method indicated at A, fig. 512, which shows the water supply brought into the bath through a rose or jet, is also open to objection, for while the introduction of the hot water to the bath at a low level lessens the amount of steam that escapes into the apartment, there is a possibility of the water supply to the premises generally becoming polluted. The supply taps ought to be fixed so as to discharge the incoming water above the level of the overflow. A common method for iron baths is to fix screw-down bib valves inside the bath, and connect them by back nuts and unions as in fig. 514. For porcelain baths a valve provided with an elongated nozzle to overhang the bath edge is generally used.

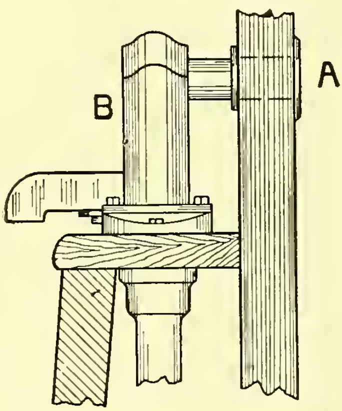


Fig. 515.—Supply Valves for Public Baths

Supply valves are mostly of the screw-down type, but valves with lever handles are also employed. The hot and cold valves can be fixed separately, or a mixing box can be utilized. For public baths it is necessary for the valves to be under the control of an attendant and operated from outside the apartment. An illustration of this type is given in fig. 515, in which A is the dial plate and valve operated outside the bathroom, and B the mixing box; the water being discharged through the nozzle fixed over the edge of the bath.

Plunge baths for hospitals and asylums should be fitted with supply valves and waste outlets, arranged so that they are opened and closed by the use of a loose key. All fittings for this class of work should be as free as possible from projections and angles which accumulate dirt, or against which the bather could be injured.

Movable Baths for Hospitals.—Baths which can be moved from place to place are necessary in hospitals. They are made in japanned or tinned sheet iron and steel, plate zinc, and tinned copper, with or without indurated wood casings. Heavy cast-iron and porcelain baths cannot be used owing to their weight, but light cast-iron baths, vitreous-enamelled, are now being employed for the purpose. The bath is usually fixed on a wrought-iron carriage, having rubber-tyred wheels and fixed or movable handles. With the ordinary plugged outlet there is a probability of an accident, due to the premature removal of the plug; so the outlet, as a rule, is in the form of a screw-down valve or plug cock, sometimes having a short metal nozzle or a flexible tube attached for convenience in emptying the bath over a gully or floor channel. Such baths are filled from a supply valve fitted with a long movable nozzle, or with a short length of hose; and, to facilitate the emptying, floor sinks (fig. 516) are often provided.

In artisans' dwellings **tip-up baths** are sometimes fixed. For the sake of lightness and strength they are made of sheet steel, metallic-enamelled, and are fitted with a hinged joint (to which the waste pipe is coupled) attached to the floor. When not in use, a bath of this kind can be raised to an upright position into a wooden enclosure made to receive it.

A variation of this bath is made of metallic-enamelled cast iron with a **swivel outlet**, and is mounted on rollers, so as to be stored under the scullery sink when not in use.

The great advantage of these tip-up or movable baths is the small amount of space which they occupy, permitting of their being fixed in a small kitchen or scullery. Hot water is in many cases supplied direct from the kitchen boiler to the bath.

Shower and other Fittings.—Accessory to the plunge bath, shower, spray, and wave attachments are often provided (fig. 517). The shower fitting

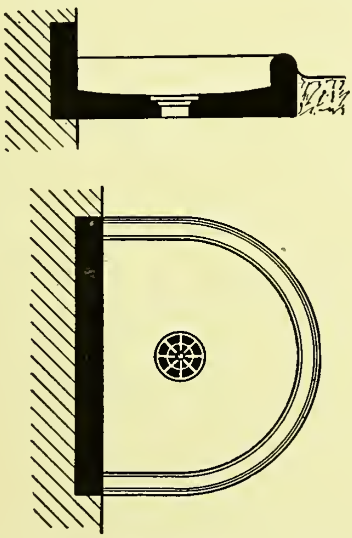


Fig. 516.—Floor Sink for Waste from Hospital Bath

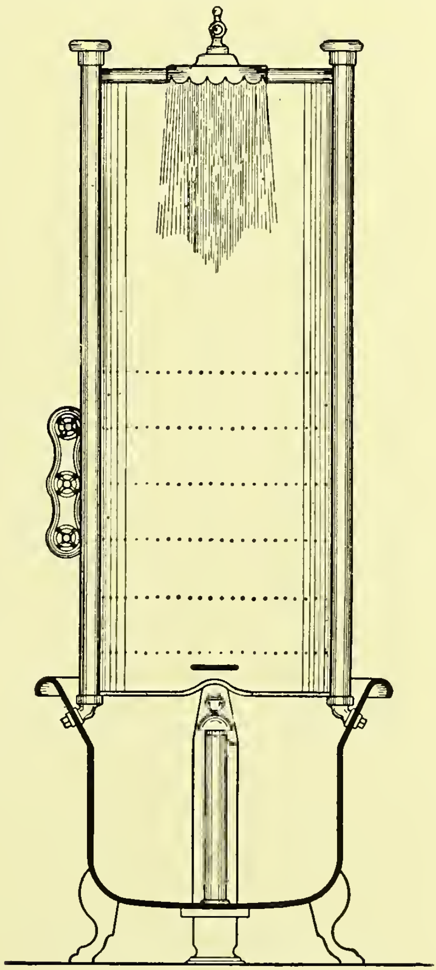


Fig. 517.—Shower and Other Fittings

consists of a fine perforated metal rose fixed 6 or 8 ft. above the bottom of the bath, at the foot end, in a curved canopy formed by sheet copper or zinc plates. In the centre of the rose a jet or douche is frequently appended. The spray is produced from a series of minute holes in the sides of the canopy, supplied by four to seven rows of pipes attached horizontally or vertically on the outside. A large orifice in the back of the enclosure originates the wave, which is placed so that the water descends upon the hips of the bather.

The canopy is often made so that it fits on the bath edge flush with the inside, but in the improved pattern (fig. 517) it stands clear of the sides, which are splayed at the top to avoid the collection of dirt. Where canopies are fitted to the ordinary taper or parallel bath, complaint is sometimes made of the floor being splashed by the spray apparatus, and to avoid this the keyhole-shaped bath, shown in fig. 518, has been introduced. Instead of the canopy, nickel-plated pipes are provided in some instances, and the enclosure consists of a waterproof curtain with rings sliding on a curved rod, or of curved plate glass.

Shower, douche, wave, and spray apparatus are now provided altogether independent of a plunge bath, and can be had with or without a canopy, the splashing being prevented in some instances by the use of a waterproof curtain. To receive the water a dished floor tray, or a metal, marble, or enamelled fireclay floor slab, with waste, is required, unless the floor is

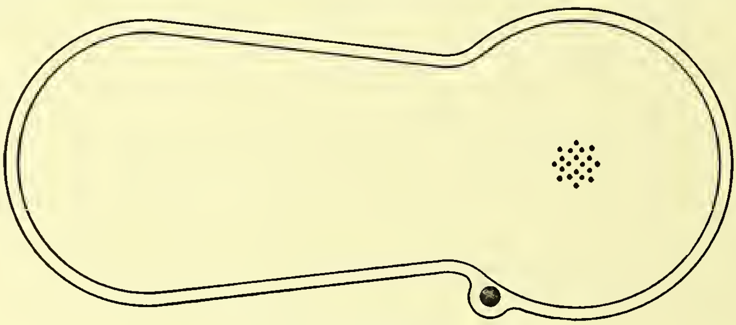


Fig. 518.—Keyhole-shaped Bath

impervious and laid with a fall to a suitable outlet. One form of this independent combination, known as a needle bath, consists of a skeleton frame formed by the supply pipe, with several rows of spray pipes of polished, tinned, or nickel-plated copper.

For large schools, where an expeditious method of bathing is required, **spray baths** are very suitable. The stall spray, which is not dissimilar in appearance to a stall urinal, has marble, slate, or fireclay divisions, with perforated pipes on the back and sides. The floor can be made to slope towards an open channel, and the hot and cold water can be passed through a mixing box controlled by an attendant.

Supply Valves.—Occasionally the supply to the shower and douche apparatus is restricted to cold water, but the wave and spray are nearly always provided with both hot and cold. Where the supply is kept distinct, separate hot and cold valves are required for each part of the apparatus. To reduce the number of valves, as well as the expense of fitting up the bath, a combination valve connected with a mixing box is now often used, which governs the hot and cold supplies to the shower, spray, &c., the valve being arranged so that it is compulsory to start the cold water first, thus avoiding any risk of scalding. By these combination valves, however, the simultaneous use of the spray, shower, &c., is impossible, whereas with individual screw-down valves governing

the various supplies all can be in operation at once. Because of this, the old-fashioned separate valves are still preferred in many instances.

A sitz bath is one taken in a sitting posture, "sitz" meaning in German "seat". The principal feature of this fitting is an ascending spray of hot or cold water, and it is frequently installed in connection with plunge baths. As a separate fitting a sitz bath is made of nickelled or tinned copper, plate zinc, enamelled fireclay, or cast iron porcelain-enamelled, in the shape of an arm-chair, and with or without wooden enclosures. In addition to an ascending spray and jet, they sometimes have a back or hip spray and a wave attachment. They are usually fitted with a form of standing waste and overflow, and a hot and cold water supply is generally attached, the valves, as a rule, being placed at the side of the fitting. If enclosed, a safe is advisable, and if fixed on a wooden floor, independent of a casing, a floor slab is an improvement.

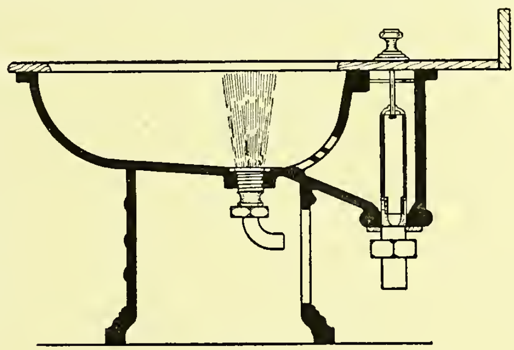


Fig. 519.—Bidet

Another form of sitting bath is **the bidet** (fig. 519), which is used for washing the lower part of the body, and also medically in the treatment of such complaints as hemorrhoids. This form of bath is not as much used in Britain as on the Continent. Made of tinned copper, white metal, or fireclay, it can be fixed in connection with a cabinet lavatory, or independently like a pedestal water closet, as in the illustration. The peculiar feature of the fitting is the ascending spray of hot and cold water. The basin can be had with a flushing rim, and the type of waste adopted is usually in the form of a standing waste and overflow as shown. Where a special bidet is not desired, a standard bidet, having an adjustable arm fitted with rising spray and mixing valve, can be fixed for use in conjunction with an ordinary water closet.

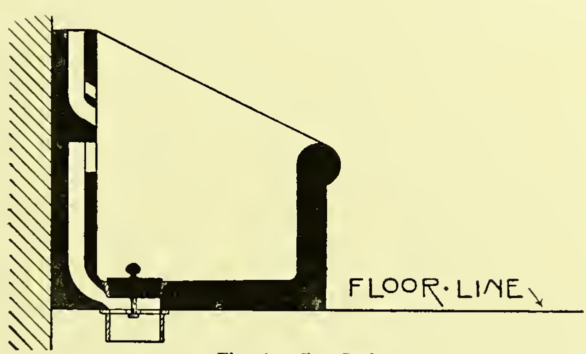


Fig. 520.—Foot Bath

Foot baths for simultaneous use by a number of persons are often required in industrial and other schools. They can be obtained in cast iron, vitreous-enamelled inside, and in glazed stoneware, the latter being preferable. As independent fittings they can be had in various sizes, a common inside size being 1 ft. $3\frac{1}{2}$ in. wide, 1 ft. $7\frac{1}{2}$ in. long, and 11 in.

deep. For fixing in ranges an average size is 1 ft. 7 in. by 1 ft. 3 in. by 10 in. When fixed in this fashion the baths should have overlap joints, and the backs ought to stand up several inches above the front. Fig. 520 illustrates a stoneware bath of this character with rolled edge.

Single baths are often fitted with a pull-up waste of the kind shown in fig. 520, but for ranges it is customary for the outlet to take the form of a plug and washer, or a combined standing waste and overflow. As for ordinary plunge baths, overflows are a necessity.

For school use baths of this kind can be supplied with water through a rose in the back, or by a spray similar to that illustrated in fig. 527. The hot and cold water supplies should, to prevent scalding, be passed through a mixing box, attached to a combined valve which renders it imperative to turn the cold water on first. The valve should be actuated by a loose key, and be in charge of an attendant.

The treatment of the waste and overflow pipes is the same as with the plunge bath, and does not call for special comment. An impervious floor is indispensable where baths of this type are fixed in ranges.

CHAPTER V

LAVATORIES

Materials.—The materials of which lavatory basins are made include painted, metallic-enamelled, and vitreous- or porcelain-enamelled iron; tinned copper; white- and buff-glazed and enamelled fireclay; and white earthenware or pottery, some of which are distinguished by special names, such as queensware, vitro-porcelain, &c.

Painted or metallic-enamelled iron should not be used except for the commonest class of work. The difference in the cost of an iron lavatory and one made of whiteware or fireclay is so trifling that the only reason that iron should be given the preference in certain cases is its greater strength. On the other hand, its appearance is much inferior and it is more difficult to keep clean. Porcelain or vitreous-enamelled iron is a great improvement, but here again the enamel is subject to "chipping".

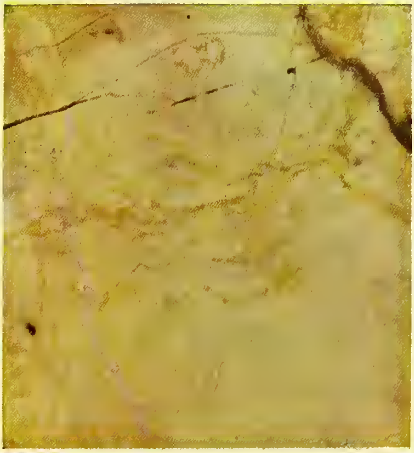
For folding lavatories, where lightness has to be taken into consideration, tinned copper is often used. It is durable, but unless it receives a thick coating the tin soon wears off.

The material most often used is pottery or earthenware, which is both non-absorbent and clean. Its strength, however, is not great, and the enamel, particularly in the cheaper varieties, is apt to "craze" or crack, which spoils the appearance of the basin. The nearest approach to perfect materials are the special forms of pottery known as vitro-porcelain and queensware, which resemble fine china. Both materials are not only vitrified throughout but are non-crazing. White-enamelled fireclay is also an excellent material. For schools, asylums, factories, and other places, where great strength is needful, there is no material equal to glazed stoneware.

No. 13. CLOUDED AFRICAN ONYX (ALGERIA)

No. 14. CLOUDED AFRICAN ONYX (ALGERIA)

No. 15. GOLDEN AFRICAN ONYX (ALGERIA)



No. 16. YELLOW (ALGERIA)

No. 17. AFRICAN BRECCIA (ALGERIA)

No. 18. ROUGE AGATE (ALGERIA)

AFRICAN ONYX, MARBLE, BRECCIA, AND AGATE

Self-contained lavatories—that is, fittings comprising basin and slab or table-top in one piece of material—have qualifications that "made-up" appliances do not possess, foremost amongst which can be put the abolition of joints and square angles, all of which tend to accumulate the dirt. This type of fitting can now be had in nearly all the materials to which reference has been made.

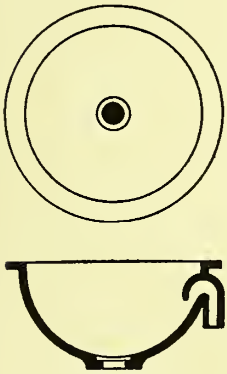


Fig. 521.—Round Basin

Made-up Lavatories.—Slabs of rubbed, polished, or enamelled slate, with earthenware basins, are used in factories, schools, asylums, &c. In hotels and private houses, onyx and marble are often employed (see Plates I, VI, XXX, and XXXII). In all made-up lavatories rectangular joints are present, and are objectionable, particularly in factories and similar places, where constant attention is lacking. In good-class residences the objection is not, perhaps, so forcible.

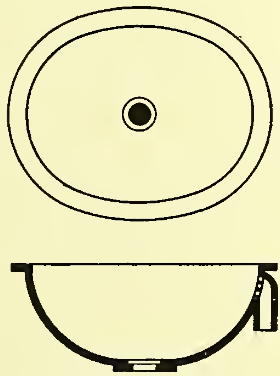


Fig. 522.—Oval Basin

Shapes of Basins.—Lavatory basins are now made in many shapes. The round and oval designs shown in plan and section in figs. 521 and 522 are now less generally used than the D shape, illustrated in figs. 523 and 524. In fig. 523 the top has a straight front, and in fig. 524 the front is recessed to allow the user to stand nearer to the basin. Both

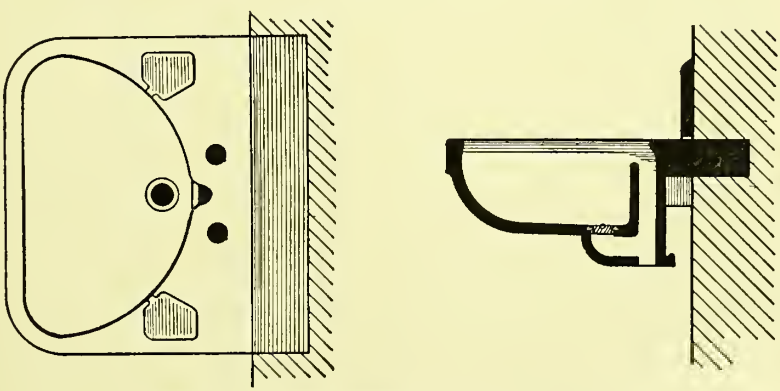


Fig. 523.—D-shaped Basin with Straight Front and Weir overflow

of these are a great improvement upon the circular or oval shape, for, as will be seen by reference to the section in fig. 523, the basins have a fall to the back, thus placing a good depth of water in a position where it is most easily used. Oblong basins (fig. 525), are also occasionally used where a very large body of water is desired. Lavatories are made for fixing either upon a flat wall or in an angle, the latter shape being very useful where space is limited.

In section, basins should have a good slope to the outlet, so as to drain the water quickly without leaving a large deposit of soap curd upon the ware.

Slabs and Skirtings. — The slab, when independent of the basin, is generally rectangular in shape; but where the slab and basin are made in one piece of ware, the front of the slab frequently follows the configuration of the basin. In all cases the slab should have a skirting at

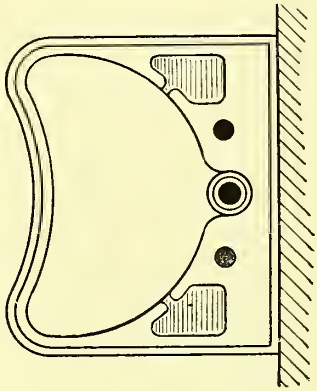


Fig. 524.—D-shaped Basin with Recessed Front and Standing Waste

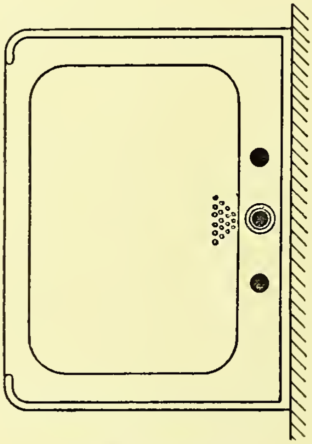


Fig. 525.—Oblong Basin

the back to prevent the walls from being damaged by the splashing of the water. The top, with a skirting 3 to 4 in. high, can be had in one piece of ware, or separate skirtings 3 to 15 in. in height can be fixed as shown in fig. 523. If the slabs or tops are made with a level surface, some of the water splashed on to them will fall to the floor. To obviate this they require to be dished in the manner illustrated in fig. 526.

One or more sinkings should be made in the top to form **soap dishes.** At one time it was a common practice to allow the water to fall into the dish and drain away through a few perforations and a small inaccessible tube into the waste pipe. The small tube speedily choked up, however, and was thus rendered useless. It is now usual to connect the soap dish with the basin itself by one or more grooves, as in fig. 523, which is an improvement.

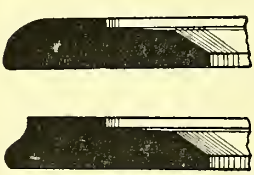


Fig. 526.—Dished Lavatory Slabs

Sizes of Basins.—Basins as small as 9 in. in diameter can be obtained, and there are many intermediate sizes up to the very large oblong basin measuring $24\frac{1}{2}$ in. by $16\frac{1}{4}$ in. inside. Top slabs for single basins vary from 1 ft. 8 in. by 1 ft. 4 in. to 3 ft. $3\frac{3}{4}$ in. by 2 ft. $4\frac{1}{2}$ in. Marble slabs for double basins average about 5 ft. 6 in. by 2 ft. 2 in., and for triple basins 8 ft. by 2 ft. 3 in. In the best ranges of lavatories the space per person allowed is 2 ft. 8 in.; in medium-class work about 2 ft. 2 in.; and for school fittings 1 ft. 8 in.

Constant-stream Lavatories. — For private houses the basins are mostly

arranged to retain water by means of a plug of some description, and are filled and emptied at the will of the user; but in schools, asylums, and public institutions the danger of infectious or contagious diseases being spread by several persons using the same water has resulted in the adoption of "constant-stream" or "spray" lavatories, by which it is made impossible for different persons to wash in the same water. As the name denotes, running water is used, the lavatories being unprovided with waste fittings to retain the water.

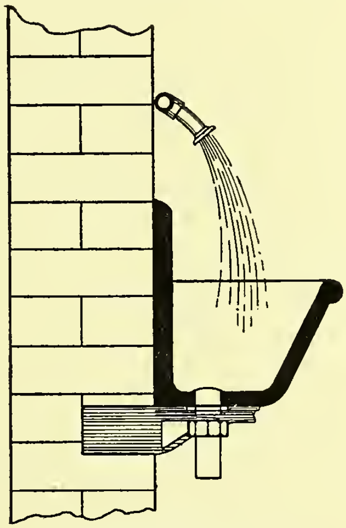


Fig. 527.—Trough Lavatory

One shape of lavatory is the trough, shown in section in fig. 527, which is fitted with a waste outlet at the lowest end for discharging into an open channel or for connection to a waste pipe. The troughs are made of fireclay or vitreous-enamelled cast iron in separate pieces from 2 ft. to 3 ft. 4 in. long, 1 ft. to 1 ft. 3 in. wide, and about 6 in. deep, and can be fixed in a range or in sections. They are made with or without a high back and enamelled-iron waste pipes, and can be fixed against a wall—in which case they should be carried on cantilevers—or in a double range, independently of the walls, and supported by enamelled-iron standards.

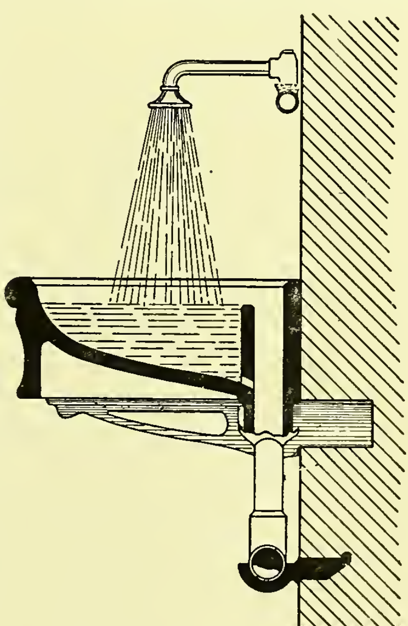


Fig. 528.—Spray or Cascade Lavatory

A supply of water is provided to the trough by means of a number of sprays fixed 1 ft. 6 in. or 1 ft. 8 in. apart and about 1 ft. to 1 ft. 6 in. above the trough. The sprays can be governed by one valve at the end of the range by the attendant in charge, in which case the spray nearest the end of the trough should be arranged so as to be used, if need be, separately. Instead of one common valve, screw-down valves, operated by a swing arm, can be fixed, so that each individual user can start or shut off the supply.

An important form of "**spray**" or "**cascade**" **lavatory**, shown in fig. 528, consists of a basin 14 in. by 10 in., provided with a large open overflow, but without a waste plug. The basin is charged from the spray, and the surplus water falls over the weir into the waste pipe. To drain the basin a small hole is provided at the bottom as shown.

A somewhat similar fitting is illustrated in fig. 529, but in this case, instead of a spray or rose valve, the water is brought into the basin through a perforated flushing rim, supplied by a common tap controlled by the attendant. The flushing rim is a distinct advantage, as it cleanses the basin of the soapy scum that settles in it.

Fig. 529 is an excellent form for schools, and the other types of constant-stream lavatories are particularly suitable for hospitals or public institutions. By the use of these lavatories not only is the risk of infection lessened, but a larger number of persons can wash in a given time than is possible with the usual plugged basin, which necessitates a waste of time during the emptying and recharging of the appliance. Objection is sometimes taken to this form of lavatory, owing to the splashing which takes place either accidentally or purposely, and to the waste of water through inattention.

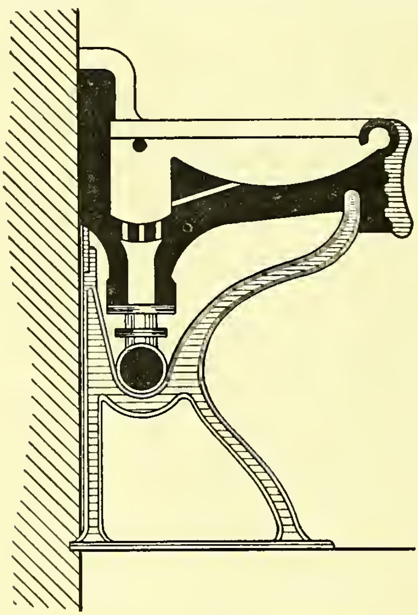


Fig. 529.—Lavatory with Flushing Rim

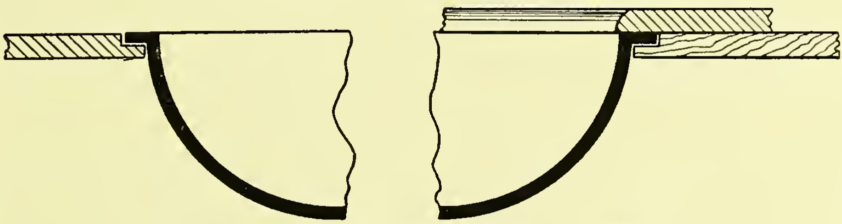
Hospital Lavatories. — For infirmaries and hospitals, and particularly operating theatres, specially arranged appliances are essential. Basins of strong vitro-porcelain or white-glazed fireclay are the best, and it is usual to fix the basins on vitreous-enamelled iron cantilevers or brackets, clear of the walls. All angles and corners of the basins should be rounded, and special care taken to exclude all mouldings and projections in which dirt or dust could accumulate. Movable glass slabs, about $\frac{3}{4}$ in. in thickness, are often employed instead of fireclay tops, and glass shelves, supported on iron cantilevers and held in position by "clips" or catches, are provided as accessories.

Supply taps of brass or gun metal, polished or nickel-plated and without sharp arrises, are now made specially for hospital work, and it is necessary that the hot- and cold-water supply valves, as well as the waste, should be fitted with levers capable of operation by the feet, knee, or elbow, so as to avoid soiling the appliances. For knee or elbow action, the levers ought to be fitted with vulcanite or rubber pads. Frequently, also, swivel arms with douche and spray are attached. The valves can be kept separate, or a mixing box provided, in which case the valve must be arranged so that the cold water is turned on before the hot; otherwise there will be a risk of scalding the hands. The waste apparatus illustrated in fig. 532 is a suitable form of valve for knee or treadle action.

The constant-stream lavatory shown in fig. 528 is very useful, and any ordinary basin, if fitted with a plain grating instead of a plug outlet,

together with a spray and douche, can easily be converted into a spray or constant-stream lavatory for hospital use.

Basins Attached to Slabs.—Basins are attached to the marble or slate slabs in diverse fashions. No. 1, fig. 530, shows a basin the rim of which is let into a prepared rebate in the slate top and bedded in red-lead cement. It is a bad arrangement, as the basin is easily loosened and then allows the water to pass between the rim and the slate. Another and slightly improved method is illustrated in No. 2. In this case a range of basins is carried by a wood shelf, and the slate top is fitted on as shown, the joint being variously made with mastic cement or with the aid of a rubber ring. Neither method is satisfactory, as the rims of the basins are frequently warped, and difficult to fit to the level surface of the slate. If the flange or rim of the basin is ground perfectly level, a water-tight joint will be secured with little trouble, as the basin can then be fixed securely by means of small metal lugs screwed



No. 1 No. 2

Fig. 530.—Basins and Slate Slabs

to the under side of the slab. In this way a reliable joint is made. If a cementing material is needed for marble slabs, plaster of Paris or Keene's cement should be employed. On no account ought oil putty to be used, as it will stain the marble.

Waste Outlets.—The remarks on sink-waste outlets apply in a great measure to lavatory basins. One of the most noticeable errors of construction in the past has been the small size of the sinkings and outlets, the plug in some cases having a diameter of ½ in. only. With a small orifice a quick emptying of the basin is impossible, and proper cleansing of the waste pipe is unlikely. The grating fitted to the washer is an additional drawback, as its perforations are usually so small that they are easily choked by an accumulation of soap and fluff. All basin outlets should be arranged so that a 1¼-in. union can be used, and the mouth should be enlarged so as to accelerate the flow of water into the waste pipe. Trap-ventilating pipes are usually necessary for quick-waste outlets, as there is a greater risk of siphonage.

Waste Plugs.—The most familiar type of outlet is the hollow lining fitted with a plug, and for all ordinary conditions its use is general. A chain is usually attached for the purpose of preventing the plug being mislaid, but instead of the chain a spindle of the kind illustrated in fig. 538 is sometimes used, a projection being formed in the basin or a metal guide fixed to it, through which the spindle works. A still simpler arrangement, which is particularly useful for schools and factories,

is that shown in No. 2, fig. 534, which consists of a plug attached to a short spindle operating through the centre of the grated outlet. In both instances the plug, on being lifted up, is kept in position by a slight turn of the handle.

Standing wastes serving also as overflows have been very largely adopted for lavatory basins. In the older type, the fitting was generally hidden in a small chamber at the back of the basin, as shown in fig. 531, into which the water escaped by means of a number of perforations in and near the bottom of the basin. Although, perhaps, it is hardly fair to condemn *in toto* hidden wastes that can be lifted out to be cleansed, it must be admitted that they are objectionable, as, being out of sight, they are nearly always neglected and allowed to become foul.

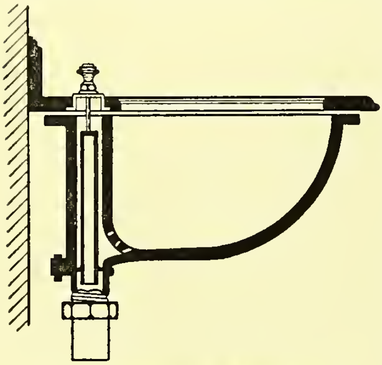


Fig 531.—Concealed Standing Waste

The exposed standing waste has been much favoured for some time. The waste can be entirely independent of the basin, as in fig. 488, or fitted with a spindle, working through a metal guide and arranged so that, on being lifted up, it can be held in position by a slight turn of the handle or knob attached.

In fig. 532 is shown a special **quick-waste outlet** at the back of the basin. The waste orifice is open, and is covered only by a hinged metal grating. The valve seating is made in the earthenware, the opening being closed by a soft rubber disc attached to the valve, which is operated by a turn of the lever handle on the top of the lavatory. The overflow takes the form of a weir, protected by a hinged metal grating.

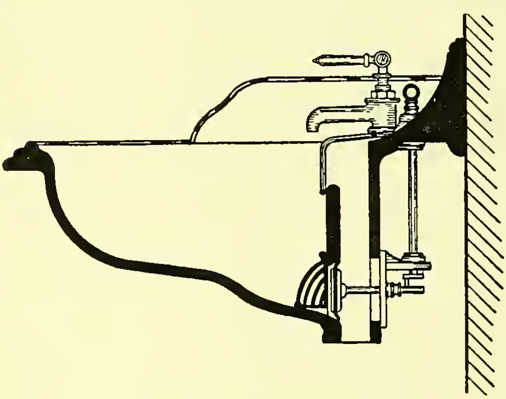
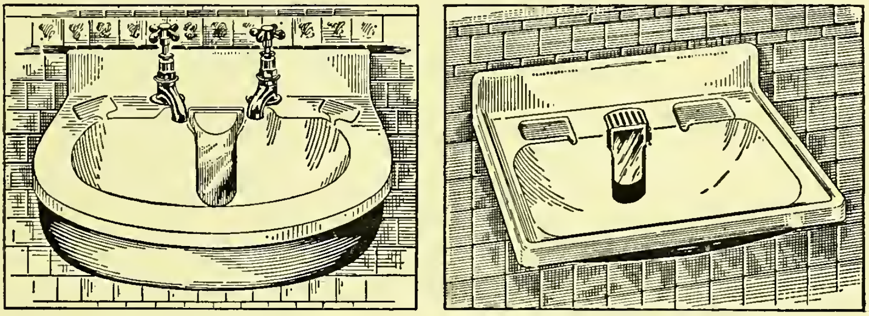


Fig. 532.—Quick-waste Outlet

Gate wastes have recently been introduced, and possess many advantages. The outlet is in a recess at the back of the basin, and a "gate" is placed in front of the recess (fig. 533) when the basin is in use. Various arrangements are adopted. In the simplest the gate is a loose, flat piece of vulcanite with flexible edges, and when it is in position the basin can be filled to the top of the gate, the pressure of water being relied upon to make a tight joint between the flexible edges of the gate and the pottery of the basin. Surplus water flows over the gate into the recess in which the outlet is placed. In other arrangements the gate is of metal fitting closely against a metal frame securely jointed to the pottery, or sliding in a grooved metal frame similarly fixed. The metal gate may be so arranged that it

can be raised to allow the water to escape, but can be entirely removed only after taking out a screw. One advantage of the arrangement is that the trap can be made in one piece with the basin itself, and can be kept clean by means of a brush passed through it from the basin. The same type of waste has also been applied to sinks and baths.

For **hospital lavatories**, plug or standing wastes are mostly employed, with a clutch or lift-up action operated by elbow, knee, or foot pressure,

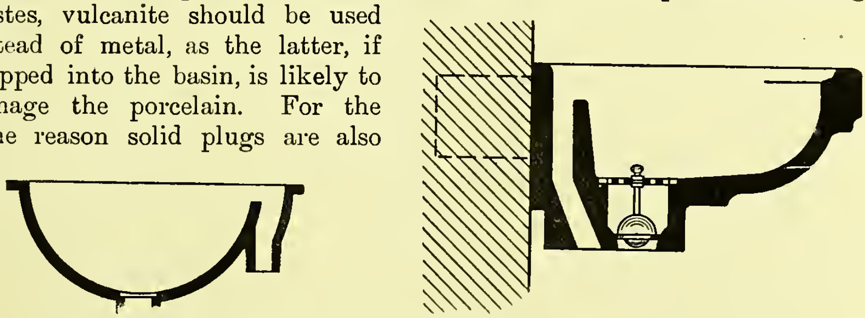


No. 1 No. 2

Fig. 533.—Basins with Gate Wastes

so as to avoid soiling any portion of the fitting with the hands. When worked in this way the standing waste is usually provided with a number of slots in the lower part below the seating, as shown in fig. 535.

Materials.—Standing wastes and plugs are mostly made of brass, either polished or nickel-plated, but it is important that, for independent standing wastes, vulcanite should be used instead of metal, as the latter, if dropped into the basin, is likely to damage the porcelain. For the same reason solid plugs are also



No. 1 No. 2

Fig. 534.—Pottery Overflows with Open Tops

best if made of vulcanite, woodite, or rubber. Where the waste is attached to a lever or handle, the use of metal is permissible.

Overflows.—Many basins are still fitted with overflows in the shape of a few small perforations in the side of the basin, discharging into a pottery arm (as shown in fig. 522), to which a separate pipe has to be fitted and connected to the waste pipe. In some instances, instead of perforations, an outlet is formed in the basin and is covered with a shell, as illustrated in fig. 521. Both methods are objectionable, as the opening is generally totally inadequate to carry off the water supplied through the hot and cold services, even when the pressure of water is only

moderate, and, in addition, the overflow arm and pipe are inaccessible for cleansing.

Fig. 534, No. 1, illustrates an improved pottery arm with an open top for access. To a great extent, however, the pottery arm is being discarded in favour of the overflows shown in fig. 523 and No. 2, fig. 534, which are made in the basin itself, the overflow taking the form of a weir, and discharging into the waste below the plug. By providing an overflow of this kind, which can be covered by a removable metal grating, it is practicable to insert a small brush for cleaning, and to maintain the overflow in a clean state. This type of overflow is unquestionably a good one, but it is possible that the best is the exposed standing or trumpet overflow, as it can be lifted out and scalded without difficulty.

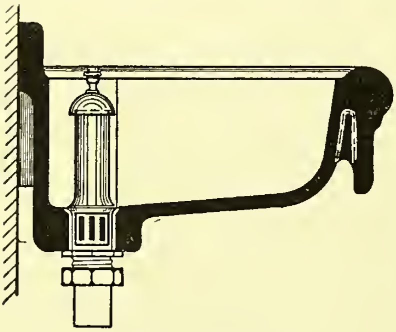


Fig. 535.—Siphonic Overflow

Siphonic Overflow.—A special combined standing waste and overflow is illustrated in fig. 535. The overflow is siphonic in its working, the metal tube being fitted with a dome, the bottom edge of which is below the top edge of the tube. On the water in the basin rising above the top of the dome, it discharges through a small hole into the tube, driving the air before it and thus starting the siphon, which continues in action until the level of the water falls below the bottom edge of the dome. A stud is fitted to the waste, and slides in a guide attached to a metal bracket. By lifting the waste and giving it a slight turn, the stud fits into a slot and holds the plug in position free of the waste outlet. In many quarters this appliance is deservedly approved, but if an ordinary open overflow is of adequate size, no difficulty will be experienced in discharging the surplus water.

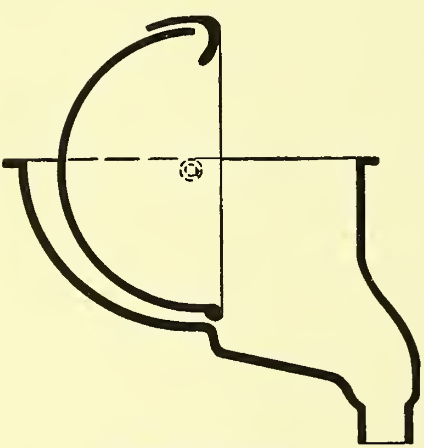


Fig. 536.—Tip-up Lavatory

For one or two other forms of overflows, which can be utilized for lavatories, the reader is referred to Chapter III.

Tip-up Basins.—The great advantage of the tip-up basin is the quickness with which it can be emptied of its contents, and another advantage is that the contents are discharged without leaving a sediment of dirty soap curd in the basin. On the other hand, the tip-up lavatory has been objected to on account of the splashing which occurs during the emptying of the basin, the accumulation of filth in the receiver, and the difficulty of keeping the latter clean; but while these drawbacks were present in the original type

of basin, with its metal receiver and immovable basin, they cannot be urged with the same degree of truth against its modern counterpart.

Fig. 536 illustrates a good form of basin and receiver, both made in white earthenware. The basin is fitted with two metal bushes on the outside, which swing upon pivots projecting from the receiver. The basin can be lifted out to enable the under side of the basin, as well as the surface of the container, to be cleansed. The containers are fitted into marble or slate slabs, and indiarubber buffers are fitted for the basin to impinge against.

Folding Lavatories.—For positions where the appearance of an ordinary lavatory would be undesirable, or where the space is limited, as in offices and railway carriages, folding lavatories are frequently fixed. They are self-contained, and when fixed on the face of a wall occupy about one-third of the space of an ordinary lavatory. The basins and receivers are usually of tinned copper and porcelain, both materials being more suitable than iron or zinc, which are also occasionally used.

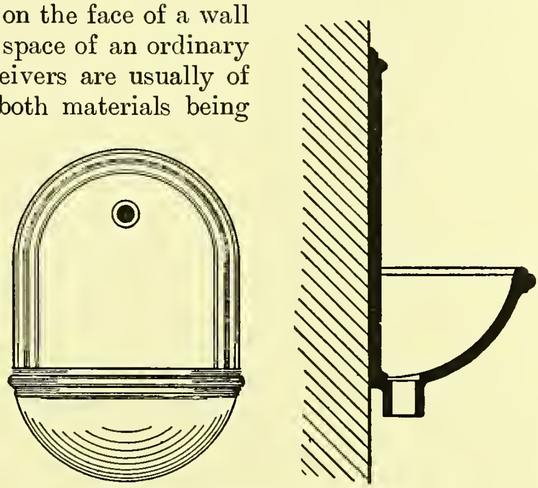


Fig. 537.—Hand Basins

The lavatories are of two kinds, one being suitable for positions where a water supply and waste pipe are available, while for the other a small storage tank and a movable waste receiver (to be emptied by hand) are necessary. In size they vary from $22\frac{1}{2}$ in. high by 20 in. wide and 9 in. deep to 5 ft. 6 in. by 1 ft. 10 in. by 9 in. The basin, which usually has a projecting rim to prevent splashing, is attached to a fall-down flap, and the contents are emptied into the receiver on the flap being again lifted into its place. Soap dishes and other accessories are generally provided. The wooden casing should in all cases be lined with tinned copper to prevent the absorption of filth.

Occasionally small flat- or angle-backed **hand basins** of enamelled iron or porcelain (fig. 537) are fixed with or without flushing rims. They are really only suitable for washing the hands, and are not much in demand in this country. In size the basins range from 13 in. by 10 in. to 19 in. by 17 in. over all, and they are mostly provided with a high back having an orifice for the supply valve.

In private houses **cabinet lavatories** are often preferred, polished mahogany, walnut, oak, and other woods being used in their construction. Any kind of basin can be used, but a marble slab is usually provided. From a sanitary point of view the cabinet is inferior to the open lavatory.

Accessory to the cabinet, a bidet, urinal, or footbath is often attached, fitted with telescopic joints, both as regards the supply pipes and wastes, to

allow the appliance to be drawn out from the cabinet. While the combination of a footbath with a lavatory may not be indefensible, little can be said in favour of the incorporation of a bidet or urinal. These should be reserved for a suitable apartment, where the wastes can be treated independently of the lavatory. In London the connection of the wastes from the lavatory and the other fittings would not be permitted.

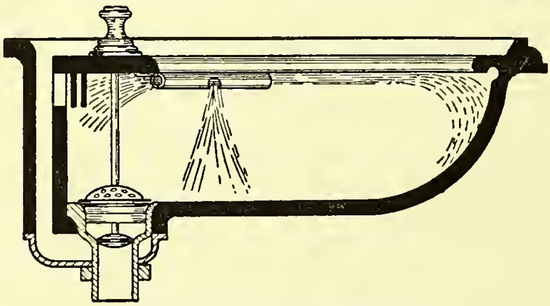


Fig. 538.—Basin with Flushing Rim

Flushing-rim Basins.—In the majority of plugged basins it is a difficult matter to get rid of the sediment of soap curds, and the basin requires to be cleansed before it is fit to be used again. To obviate this deposit, basins with perforated flushing rims or spreaders (fig. 538) have been used, which adequately wash the surface. Even where this provision is made, however, the basins should be cleansed by turning the supply tap on for a moment after the basin is emptied; otherwise the curd will dry on the surface and be difficult to move the next time the basin is flushed.

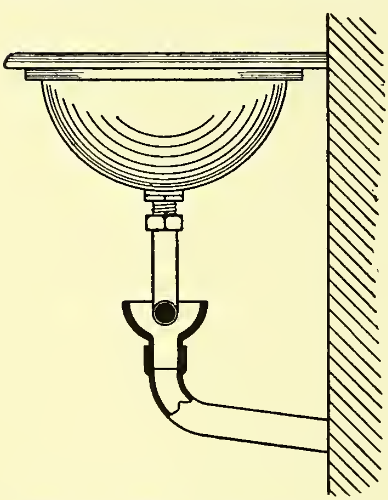
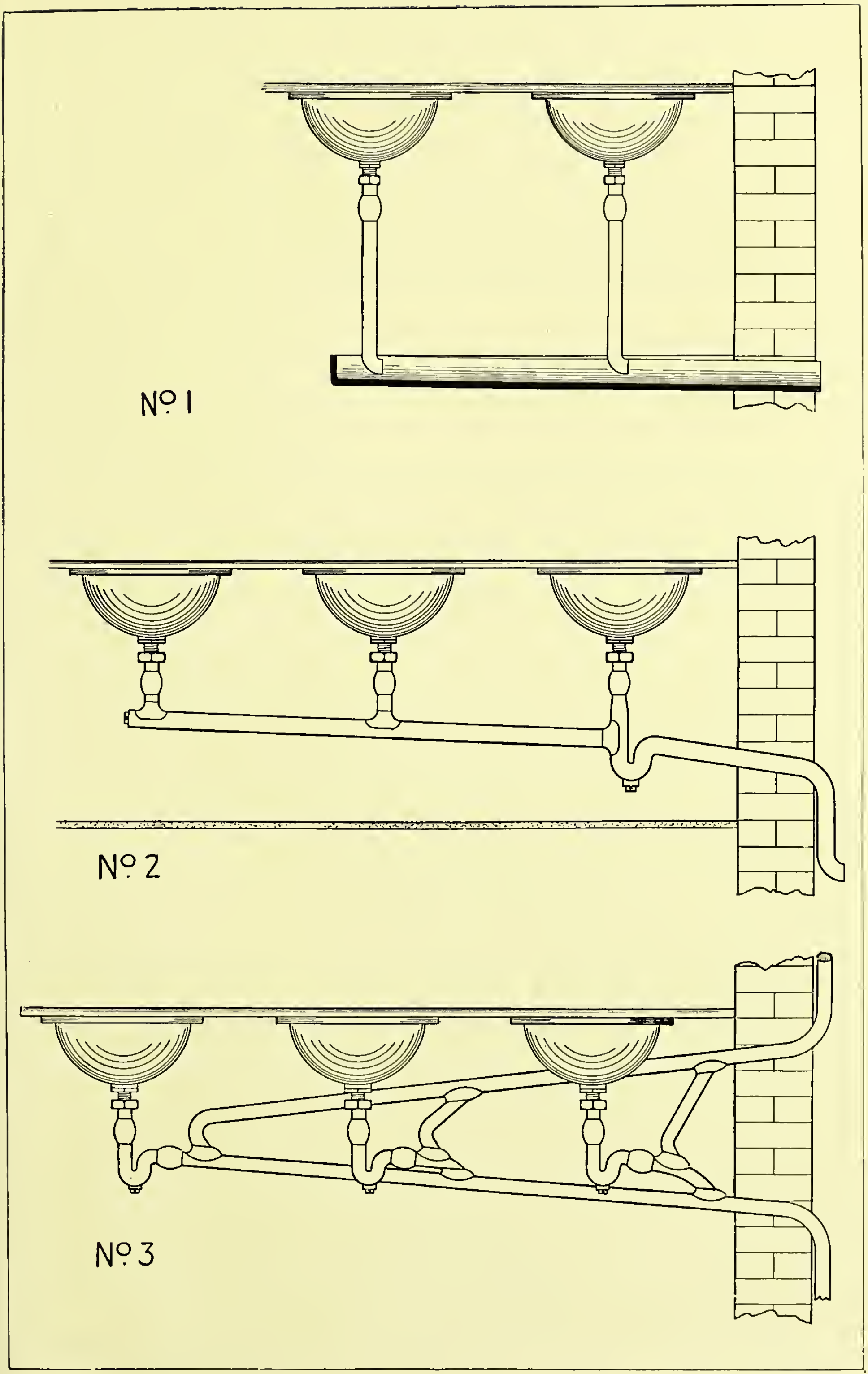


Fig. 539.—Basins Discharging into Open Channel

Waste Pipes.—Single lavatories are generally trapped in the ordinary way, but a greater amount of latitude is observed in the treatment of groups of fittings. Thus, a very common arrangement is to discharge a range of basins, by means of short untrapped waste pipes, into an open channel immediately under the basins, as shown in fig. 539, or at the floor level, as illustrated in No. 1, Plate XXXIII, which in turn discharges over a gully, generally outside but sometimes within the apartment. For this method it is claimed that stoppages are less likely to take place; and that, for situations where the treatment of the fittings is not of the most gentle description, the waste pipes are not so likely to get out of order. It must, however, be said that, unless constant attention is paid to the cleansing of the channel and waste pipes by hand, they become thickly encrusted with a deposit of filth and eventuate in nuisance.

Another method of arranging the wastes from a group of fittings is illustrated in No. 2, Plate XXXIII, where a horizontal waste pipe, 2 to 3 in. in diameter, is fixed under the basins to receive the branch waste connections from the several basins. Occasionally a trap is provided at the end



WASTE-PIPES FROM LAVATORY RANGES

of the range as shown, but in many cases the waste pipe discharges over a gully, or into a hopper head, without the intervention of a trap.

The first objection to this method is that the dirty water, discharged through the vertical waste pipe under one basin, washes back up the horizontal pipe, leaving a deposit of soap curds on its internal surface. A second objection is that, on the contents of one basin being discharged, a puff of more or less fouled air is driven from the filth-encrusted horizontal waste, which is often much larger than is necessary, out of the open waste of the adjoining basin. The arrangement as illustrated is, however, often fitted to ranges of basins by the makers, who, it must be readily admitted, display the utmost intelligence in perfecting the details of the basin itself, and yet recommend a waste arranged in an objectionable manner.

Both these methods are freely adopted for schools, factories, and similar buildings, where they are supposed to receive regular attention at the hands of an attendant; but it is often found that the attendant (particularly in factories and workshops) neglects to give the fittings the attention which is requisite to maintain them even in a decent condition.

Trapping.—Regarded sanitarily, there is not the slightest reason for treating the waste pipes from a range of lavatories differently from isolated basins. A trap of a suitable kind ought to be fixed immediately under each basin, and connected to a waste pipe discharging under the grating of a gully trap, but above the level of the standing water. In London, where a waste pipe which discharges outside is attached, the by-laws in force require a trap to be fixed immediately under the fitting, and it is only by arranging the waste pipes in the way indicated in No. 3, Plate XXXIII, with adequate means of ventilation, that the waste can be claimed to be satisfactory.

It is not desirable that the waste pipe should be turned into a hopper head, or allowed to discharge above the gully grating, as the hopper may become foul and the grating is liable to be clogged with soapy matters. Short waste pipes, which discharge into a channel, should be held in position by clips so as to be easily detachable to permit of cleansing.

Trap Ventilation.—For single fittings the trap and waste pipe can be ventilated by a puff pipe of the same diameter, turned through the external wall above the level of the lavatory, as shown in the case of the sink illustrated in fig. 500, but for groups of fittings the main waste pipe ought to be carried above the highest basin to a position that ensures a safe outlet for foul air, and trap-ventilating pipes ought to be provided in the usual position. It is often economical to connect the lavatory to a bath waste, and to this there is no objection, provided that suitable trap-ventilating pipes are fixed to prevent siphonage.

Materials for Waste Pipes.—Polished brass and copper waste pipes are used for high-class lavatories where exposed, and vitreous-enamelled iron for hospital fittings. For a commoner class of work galvanized and metallic-enamelled pipes are used, but for general use lead pipes are the most satisfactory. Where the lavatory is supplied with cold water only, wiped joints can be employed, but where hot water is present, expansion joints are necessary. If iron pipes are used, the metal should be vitreous- or glass-

enamelled, or coated with a suitable solution, and the joints should be either flanged or made with metallic lead properly caulked.

Size of Pipes.—For single lavatories a waste pipe $1\frac{1}{4}$ in. in diameter is ample, but for groups of fittings, pipes $1\frac{1}{2}$ in. to 2 in. or more in diameter, according to the number of attached basins, are required. The ventilating pipes, both main and branch, should be of the same size as the waste pipes.

Enclosures.—Years ago lavatories were seldom seen without enclosures, but latterly, with the exception of the cabinet type, enclosed lavatories are seldom seen. This alteration is due not only to an advanced conception of what constitutes a sanitary fitting, but also to an improvement in the manner of carrying out the plumber's work, and to the adoption of polished and nickel-plated metal waste pipes, traps, and fittings, rendering an enclosure for the purpose of hiding the waste and service pipes unnecessary. Considered from a sanitary aspect, an open lavatory is preferable in all cases.

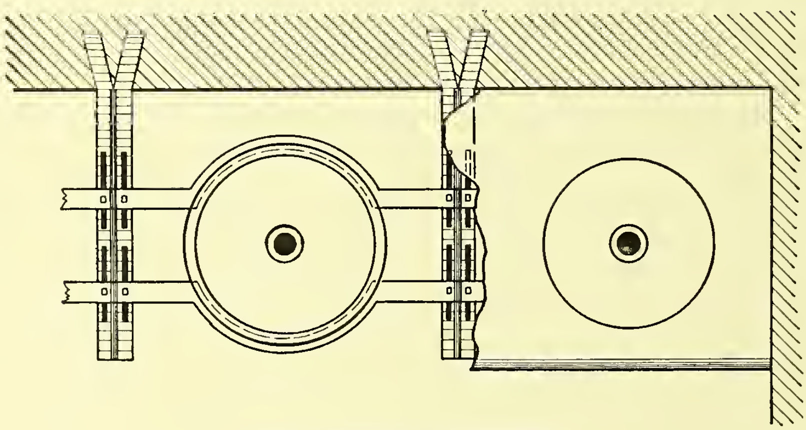


Fig. 540.—Cantilevers and Metal Rings

Supports.—The use of wood supports for lavatories is extremely undesirable. Iron supports, metallic-, vitreous-, or glass-enamelled, are now most generally used, in addition to polished or nickel-plated brass and gun metal, and are superior in every respect to wood. Supports sometimes take the form of painted iron standards of more or less intricate pattern (fig. 529), but these are objectionable by reason of the amount of exposed surface and the number of quirks and corners in which dirt can accumulate. Standards of this kind are preferred by some for ranges, as they are often constructed to carry the horizontal waste pipe as shown; but the latter can be carried equally well by a specially made bracket of the kind shown in fig. 528. If standards are used at all, they should be of the plainest form possible, such as those illustrated in fig. 492. They can be so arranged that the legs or standards support a frame in which the basin is suspended, the back portion of the frame being screwed to the wall by small lugs.

Stoneware or metal cantilevers, with the surfaces as plain as possible, are the best form of support. They should be no larger than is necessary for the weight of the basin, and be properly pinned to the wall. This method of fixing is illustrated in figs. 527 and 528. Combined cantilevers

and metal rings to receive the basins (fig. 540) will be found especially useful for schools and factories, where strength and simplicity are required. The corbel system of fixing (fig. 523 and No. 2, fig. 534) removes the necessity for external supports, and renders the fittings suitable for hospitals and other public institutions. Slate and marble lavatory slabs are often fixed on a wood bed or carrier, as shown in No. 2, fig. 530, holes being cut to receive the basins, but if suitable brackets, cantilevers, or standards are used, the carrier can be dispensed with.

For lavatories of a high class, and those intended for use in operating theatres and hairdressers' saloons, a **shampoo attachment** is often provided. The simplest form is a flexible indiarubber tube, connected at one end to the supply tap, and having a rose and jet at the other. More elaborate kinds consist of a polished or nickel-plated metal lever arm, provided with a hinged joint, which allows the arm to be raised, depressed, or moved from side to side, the valve being generally arranged so that the water is turned on and off by the lever action of moving the arm. In many cases a mixing box for the hot and cold water is attached.

CHAPTER VI

WATER CLOSETS

Legal Requirements.—The Public Health and Factory Acts in force in London and the provinces insist upon the provision of sufficient and suitable accommodation in the way of sanitary conveniences to dwelling houses, factories, workshops, and other buildings. The local sanitary authorities, by the by-laws which they issue, may prescribe not only the form but the number to be provided, having regard to varying circumstances. Unfortunately there is no generally accepted standard, but the following tabular statement may be useful:—

Description of Premises.	Number of Water Closets Required.		Authority making Requirement.	Districts in which Requirement is Enforceable.
	Males.[1]	Females.		
Factories and Workshops.	Where less than 100 persons are employed, 1 for every 25. Where more than 100 and less than 500 are employed, 4 for the first 100, and one for every 40 after. Where more than 500 are employed, 1 for every 60.[2]	One for every 25 persons employed.	Secretary of State for Home Department.	All England and Wales, excepting London and places where the Public Health Amendment Act, 1890, is in force.

[1] Sufficient urinal accommodation must also be provided.
[2] Subject to the issuing of a certificate by the Factory Inspector.

Description of Premises.	Number of Water Closets Required.				Authority making Requirement.	Districts in which Requirement is Enforceable.
Dwelling houses occupied by more than one family.	One for every 12 persons.[1]				London County Council.	County of London.
		Girls.	Boys.[2]	Infants[2]		
Elementary Schools.	Under 30 children.	2	1	2	Board of Education.	England and Wales.
	,, 50 ,,	3	2	3		
	,, 70 ,,	4	2	3		
	,, 100 ,,	5	3	4		
	,, 150 ,,	6	3	5		
	,, 200 ,,	8	4	6		
	,, 300 ,,	12	5	8		

[1] For public health purposes two children not exceeding ten years of age are generally counted as one adult.
[2] Sufficient urinal accommodation must also be provided.

Definition.—In the category of sanitary conveniences are included water closets, earth closets, and privies. It is not intended to deal with the two last forms in the present chapter.

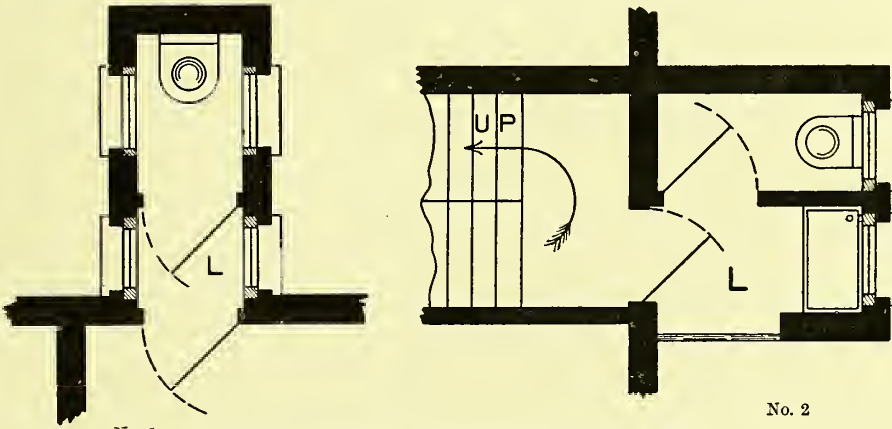
Position.—The position of water closets is of primary importance. They should be as far distant as possible from bedrooms, living rooms, and places where food is prepared or stored. For elementary schools complete disconnection is expected, and by this arrangement many of the difficulties entailed when sanitary conveniences are in close union with buildings, such as the difficulty of securing proper aërial disconnection, adequate lighting, and sufficient ventilation are avoided.

In practice, complete isolation is often found to be impracticable, and indeed in some cases undesirable, when regarded from a medical standpoint; and in view of this, certain rules are now generally adhered to in the planning and construction of the water-closet apartment. The model by-laws of the Local Government Board, upon which the majority of the codes in force are based, stipulate that one wall at least shall be an external wall. This is a reasonable requirement, and is intended to facilitate the provision of proper means for lighting and ventilating the apartment directly into the external air, and the fixing of the soil pipes outside the premises. The by-laws in force in London require also that the apartment shall abut upon an open space at least 100 superficial feet in extent, with the proviso that if the water closet is below the surface of the ground it may be directly approached from an open area having a superficies of at least 40 sq. ft. and a minimum width of 5 ft.

Where attachment to a building is obligatory, the best arrangement is secured by the projection of the apartment from the main wall of the building, as illustrated in No. 1, fig. 541. In this manner the apartment

can be adequately lighted, and the greatest possible advantage taken of the natural movement of the air to secure—what should always be aimed at—cross ventilation.

In most districts it is not allowable for a water-closet apartment to be approached directly from a room used for sleeping or living purposes; for



No. 1 No. 2

Fig. 541.—Arrangement of Water Closets in Projecting Blocks

the manufacture, preparation, or storage of food for man; or as a factory, workshop, or work place. To overcome this difficulty an intervening lobby must be provided so as entirely to separate the apartments. To this lobby independent means of lighting and ventilating should be provided. Fig. 542 illustrates a method of separating the water-closet apartment from the workroom when it is situated, as often occurs, in a corner of the latter. By an order of the Home Secretary, dated February 4, 1903, the provision of an intervening ventilated space is compulsory in factories and workshops, with an exception for existing conveniences, where the workrooms are ventilated in such a manner as to prevent air being drawn into the workrooms through the sanitary convenience.

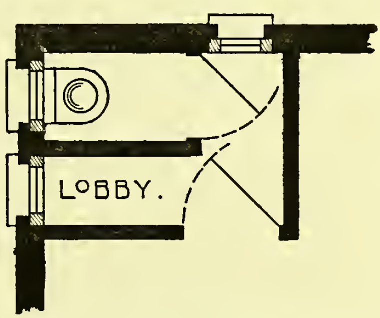


Fig. 542.—Water Closets approached from Lobbies

Partitions and Doors.—To isolate the convenience aërially, the partition dividing it from the room, from which it is approached or upon which it abuts, should be formed of brickwork or other solid materials rendered on both sides with plaster or cement. The use of lath and plaster or wooden partitions is unsatisfactory, as they fail to separate the two apartments properly. Where the water-closet apparatus is enclosed, special attention to the rendering of the walls below the seat enclosure is desirable. Where the water closets are situated inside the premises, the doors should be made to fit the openings as closely as possible; but for external water closets it is an advantage to allow a space at the top and bottom.

Size.—The water-closet apartment is often so confined as to be decidedly uncomfortable. For ordinary dwelling houses the minimum size should be 4 ft. 9 in. from front to back and 2 ft. 9 in. from side to side, with a height of 7 ft. For factories and workshops a slight reduction is permissible, but the space provided should never be less than 4 ft. by 2 ft. 3 in. by 7 ft.

Approaches.—In designing conveniences for factories, &c., care should be exercised so that the water closets intended for use by the opposite sexes are provided with separate approaches. By the order previously referred to this is made compulsory. For places where it is necessary to construct such conveniences so that they abut, fig. 543 illustrates one method of complying with the requirement.

Lighting and Ventilation.—The lighting and ventilation of the apartment are of supreme importance. For the lighting, an external window having a superficies of at least 2 ft. is necessary, and to assist in the ventilation it should be made to open. The ventilation of the apartment should not, however, depend solely upon the window. By the provision of sufficient inlets and outlets in the form of air bricks, air shafts, or louvres, a constant movement of the air should be ensured; and in cases where the application of natural means is difficult, mechanical methods should be resorted to. The provision of at least one air brick is frequently insisted upon; but it is necessary to provide both an inlet and an outlet, so as to obtain a movement of the air. If adequate inlets and outlets are not provided, there will be a danger of effluvia being drawn into the house.

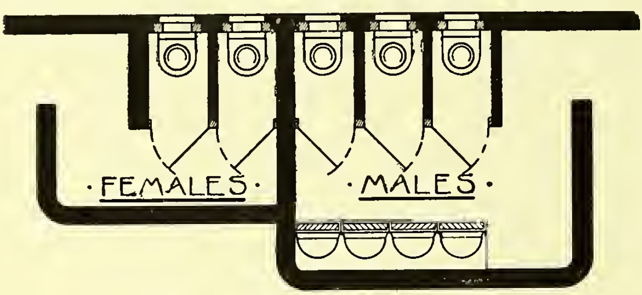


Fig. 543.—Groups of Water Closets for the Two Sexes

Without the application of mechanical means, the ventilation of a sanitary apartment, so that the air is withheld from the other portion of the premises, is often exceedingly difficult, particularly where cross ventilation, as shown in No. 1, fig. 541, is impracticable. In dealing with public underground lavatories and similar conveniences, special conditions have to be taken into consideration

To avoid the absorption of liquid filth, **the walls and floors** are best constructed of or lined with an impervious material. The simplest and cheapest form is Portland cement, trowelled to a smooth surface, and, if desired, painted in oil colour. Tiles, opalite, and marble linings are excellent for the purpose, presenting a clean and neat appearance. If tiles are used, white should be chosen in preference to colours, as the accumulation of filth is the more easily detected.

Bad Types of Water Closets.—Noteworthy among the discredited fittings is *the pan closet*, illustrated in fig. 544. Its principal faults are the presence of a copper pan to hold the water intended to receive the deposited matters,

and the existence of a large container or receiver, both of which speedily become foul and emit offensive smells every time the apparatus is used. It is impracticable to keep the pan and container clean while in use, as the fouled part is hidden and cannot be cleaned without taking the apparatus to pieces. It is also a common experience to find the basin flushed only by a spreader, as shown, and fixed over a trap of the insanitary D shape.

Another type is *the long-hopper closet* (fig. 545). It possesses a large fouling surface, and, owing to its shape, the fæcal matter is continually deposited

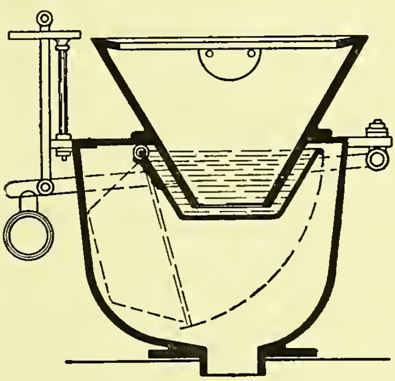


Fig. 544.—Pan Closet (Insanitary)

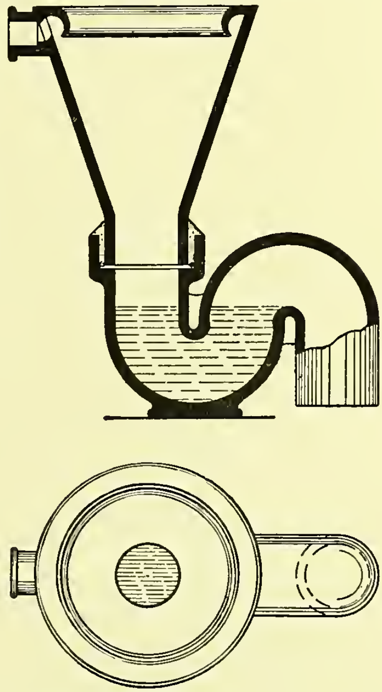


Fig. 545.—Long-hopper Closet (Defective)

upon its sides. To this defect is added in many instances the want of a proper flushing rim, and the ineffective means of flushing provided by a side-inlet arm, which gives the water—often supplied through a plug cock or screw-down valve—a circular movement, by which its scouring force is minimized.

A replica in a slightly altered form is the *short-hopper* or *cottage pan*, illustrated in fig. 546. Here, again, the basin, owing to its shape, is constantly fouled by the deposit of excremental matter.

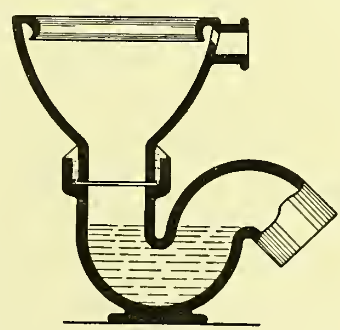


Fig. 546.—Short-hopper Closet (Defective)

In fig. 547 is shown a somewhat modern form, known as *the wash-out closet*, which it is impossible to speak well of. The basin holds a small quantity of water, 1 to 1½ in. in depth, which receives the waste matters, but does not immerse them. Not uncommonly an ordinary flush of water fails altogether to dislodge the fæcal matter from its position, and in many more cases the contents of the basin are simply pushed out into the trap, fouling the edges of the basin during the passage, instead of being immediately washed through the trap into the drain or soil pipe.

Fig. 548 is representative of a type that fortunately is now universally condemned. The kind is that known as *the trapless closet,* and the variety illustrated is provided with twin basins—a large one to receive the waste matters, and a smaller one which is fitted with a supply valve. The demerits of this form of closet are obvious. Neither of the basins is provided with a flushing rim, and the exposed surfaces become very foul. The appliance is without a trap, and the only method of preventing the escape of soil-pipe and drain air into the house is the valve, which fits into the outgo of the basin for the purpose of retaining a quantity of water to receive the waste matters. Should this valve get out of order—and the lodgment of a piece of paper between the valve and its seating is sufficient to effect this—the basin is emptied of its contents, and fouled air is permitted to find an entry into the house. As will be noticed, also, the overflow, which discharges beneath the valve, is only disconnected from the air

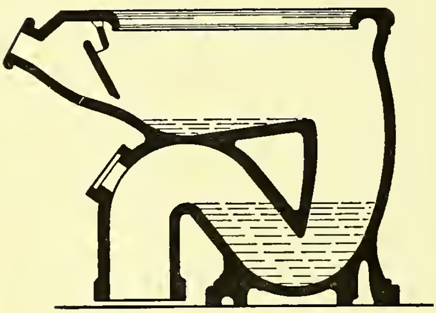


Fig. 547.—Wash-out Closet (Defective)

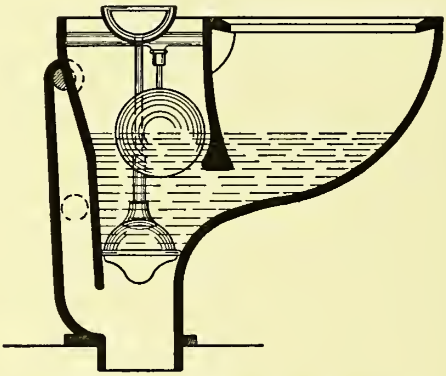


Fig. 548.—Twin-basin Trapless Closet (Insanitary)

of the water-closet apartment by the waterseal made by the dipping of the division between the basins into the water. Should the quantity of water in the basin be reduced to a level below the dip, fouled air is allowed to pass and mingle with the air of the apartment. Another drawback is the waste of water, which occurs when the valve allows the basin to drain empty; for so long as there is a leakage, water is constantly supplied by the ball valve (which can only be shut off by the water rising to a certain height in the basin) until the storage cistern is emptied.

One defect common to all pan and trapless closets, as illustrated, is the position of the outlet, which is of such form and in such a position that a proper connection to the soil pipe or trap is rendered impossible.

Pan closets, trapless closets, and, in a minor degree, wash-out closets are now prohibited by many codes of by-laws in force, which disallow the container portion of the pan closet, and require a trap to be fixed immediately under all closet basins, and also specify that the basins shall hold sufficient water to receive the solid matters.

Good Types.—Whatsoever the type of water closet, certain qualifications are indispensable. The pan must be of such a shape as to permit of the fæcal matter falling free of the sides, and directly into a body of water

sufficiently large to immerse the solid matters deposited. The basin must also be made of non-absorbent material and provided with a flushing rim, and the outlet of the trap must be in a position where it can be seen and easily connected to the soil pipe.

The shape of the basin is of particular importance in the case of **wash-down closets**. The circular shape, as shown in the illustrations of hopper closets (figs. 545 and 546), is bad, for the reason that the sides are so easily fouled. The best results are obtained with a pan having a vertical or an overhanging back, which allows the fæces to fall directly into the water. In fig. 549 the back is not quite vertical. At the present time the only good type of basin to which this principle has not been applied is the valve closet, in which, however, a large body of water is maintained in the basin much closer to the seat than is usual in those of a wash-down type.

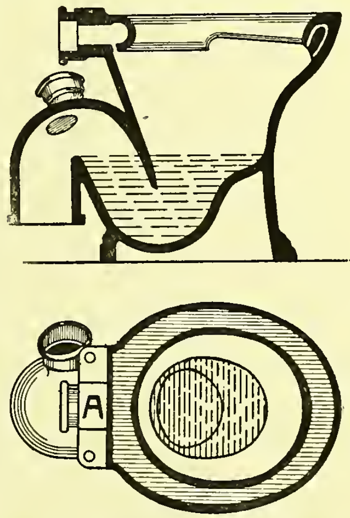


Fig. 549.—Wash-down Closet with Vented Trap

While a sufficient depth of water to immerse the solid matters is essential, it is equally important that the basin should be so shaped as to present a large surface of water for the reception of the waste matters. The body of water contained in the basin and trap, however, must not be so large—as in the case of D traps—as to be irremovable by an ordinary flush.

The best modern water closets can be divided into three classes:—(1) The valve, (2) the wash-down, (3) the siphonic closet.

A few years ago this would in all likelihood have been the order of merit and selection, but the first place would now be conceded by many authorities to the siphonic for best work, with the valve type a good second, and the wash-down taking third place for general work.

Various materials or combinations of materials are employed in the manufacture of closet apparatus, but the basin itself is now, with a few exceptions, made of glazed pottery or fireclay, and it is difficult to suggest more suitable materials. For certain purposes iron basins and traps are occasionally employed, but, generally speaking, the use of iron for this purpose meets with scant approval. Iron basins are generally lined internally with a vitreous enamel, which, if subjected to anything approaching rough usage, is chipped off, rendering the basin not only unsightly but difficult to clean. For this reason its adoption is not recommended.

Valve closets consist of two principal parts—the basin, made of pottery, and the valve box, made of iron, and usually porcelain-enamelled. A lead trap is generally fixed under the fitting. The siphonic closet is mostly made of pottery, but the pan and trap can be obtained separately and of different materials, or combined in one piece of ware. Wash-down

closets are variously made of pottery and fireclay, with combined or separate basin and trap.

The valve closet (fig. 550) certainly possesses many advantages, if the principles of construction are sound and the materials and workmanship are of the best quality. In valve closets the best types only ought to be used, as cheap forms are often insanitary and soon get out of order.

Amongst the qualifications of a good valve closet may be mentioned (*a*) its silent action; (*b*) a considerable body of water (in a good closet the water area will measure 14 in. by 12 in.) so placed as to avoid splashing, and having a large exposed surface with sufficient depth to

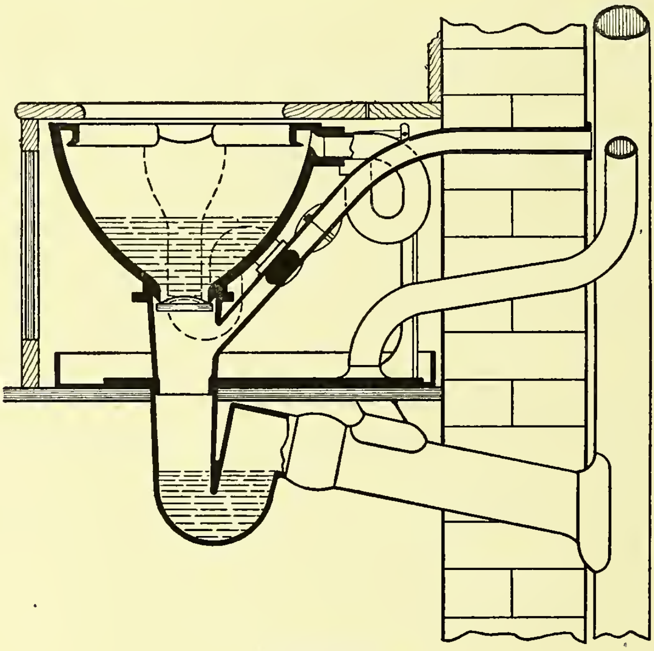


Fig. 550.—Valve Closet

immerse completely all solid matters; and (*c*) its capability of discharging instantly the contents of the basin—1 to $1\frac{1}{4}$ gal.—making it a useful flushing agent for thoroughly scouring the trap and soil pipe after each user. It is sometimes argued that it possesses too much mechanism, and for this reason constantly requires attention. In comparison with a wash-down closet—the mechanical parts of which are confined to the flushing cistern—the statement contains some truth, and for positions where the appliance is likely to be roughly or ignorantly handled, the valve closet cannot be recommended.

The greatest possible care must be exercised in fixing a valve closet, as many an apparatus, which in itself is eminently satisfactory, is rendered ineffective by being carelessly or improperly fixed. One common error is the treatment of the valve box. Reference to fig. 550 shows that provision is made for ventilating this portion of the apparatus

independently, but in some instances the purpose of this vent pipe is ignored, and the end of the pipe is simply sealed by the person fixing the closet. This is a great mistake, as the vent pipe is required to secure a frequent change of the air contained in the box, and (what is of even greater importance) to prevent the contents of the trap, attached to the basin overflow, from being siphoned out by a discharge from the closet pan. It is sufficient to carry the open end of the vent pipe into the external air, in the form of a puff pipe as shown.

The overflow pipe from the basin is variously treated by different makers, but the methods now principally adopted are its connection either with the valve box or, better still, with the vent pipe, as illustrated. It should always be trapped, the inlet end left open so as to permit of cleansing, and the flushing rim arranged so that the overflow outlet is flushed every time the apparatus is used.

Where a valve closet is intended to be used also as a urinal, or for

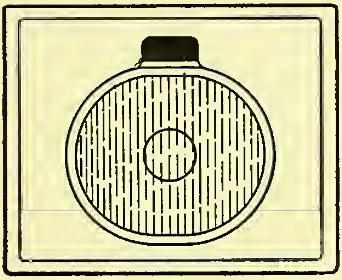


Fig. 551.—Glazed-ware Slab Top for Valve Closet

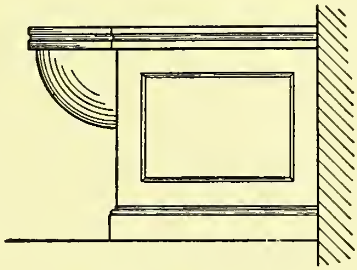


Fig. 552.—Pedestal Valve Closet

the reception of slop water, it should be fitted with a **glazed-ware slab top** of the kind shown in fig. 551, which will in great measure prevent the splashings from falling on to the floor. Special attention should also be given to the fitting of the wooden seat so as to secure a watertight joint between it and the earthenware top. A still better arrangement, where the apparatus is to be used as a urinal, is that shown in fig. 552. In this case the valve closet takes the form of a pedestal, the wooden enclosure being abolished and a glazed whiteware front and sides being substituted as shown. An additional recommendation, when used for this particular purpose, is the "bow front", which allows the person using the convenience to stand well over the basin.

Wash-down Closets.—For use under ordinary conditions this form at present holds its own. It is cheaper than the other types both in original cost and in fixing, and is capable of performing good service under conditions that militate against the success of valve or siphonic closets. In the pedestal form it is suitable for use as a urinal or slop hopper, as well as for ordinary purposes. The principal objection that is urged against this apparatus is the necessity of having a water-waste preventer with its accompanying noisy action.

The special points to be looked for are (1) a sufficiently large surface of water in the basin, (2) a good waterseal, (3) a vertical-backed basin,

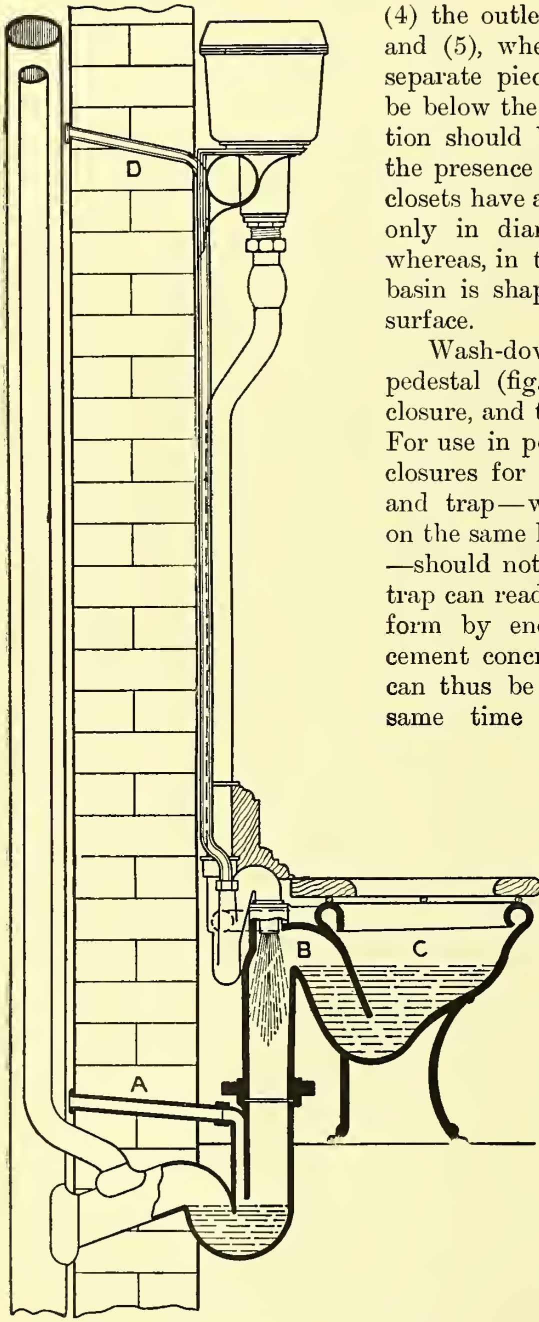


Fig. 553.—Siphonic Closet and Flush Tank

(4) the outlet of the trap above the floor, and (5), where the pan and trap are in separate pieces, the joint placed so as to be below the water line. Particular attention should be paid to the first point, *i.e.* the presence of a large water area. Many closets have a circular water area, 4 to 5 in. only in diameter, as shown in fig. 545, whereas, in the better types (fig. 549) the basin is shaped to secure a large exposed surface.

Wash-down closets in the form of a pedestal (fig. 549) do not require an enclosure, and this is obviously an advantage. For use in poor-class property, wooden enclosures for the modern short-hopper pan and trap—which is a cheap reproduction on the same lines as the pedestal illustrated—should not be suggested, as the pan and trap can readily be converted into pedestal form by enclosing them in a casing of cement concrete. The necessity of a riser can thus be done away with, and at the same time the fitting is strengthened against rough usage.

Siphonic closets are gradually forcing their way into recognition as a type of apparatus suitable for different classes of work. In fig. 553, which illustrates (*in situ*) a siphonic closet now very well known, the basin and trap are made in one piece of pottery. The outgo of the closet trap is provided with a long leg, which is connected with a second trap fitted with a vent pipe A, carried into the external air. The siphonic action is produced as follows:—Upon the siphonic flushing tank being operated, the descending water, on reaching the level of the seat, is divided into two portions, one portion passing through the arm into the rim of the basin for the purpose of flushing the sides, and the other through a siphon and jet into the crown of the trap outgo as shown.

The water from the jet drives the air down the long leg of the trap and out of the puff pipe A. In so doing a partial vacuum is caused at B, and the pressure of the atmosphere is thus taken off the surface of the water, thereby permitting the atmospheric pressure at C to force the contents out of the basin. The object of the bottom trap is to reduce the quantity of air to be brought under pressure by the falling jet of water, and in this way accelerate the formation of a partial vacuum. The siphonic action thus set up draws the contents of the basin through the trap, notwithstanding the deep seal which the latter possesses, and at the same time the basin is flushed and the trap recharged by the incoming water from the arm and flushing rim. A special water - waste preventer, having an after flush, must be fixed in conjunction with this closet.

To prevent siphonic action being set up by the discharge of a pail of water into the basin, a pipe, D, is connected to the siphon bend. On a pail of water being thrown down the apparatus, a supply of air is drawn through this pipe, thereby preventing the

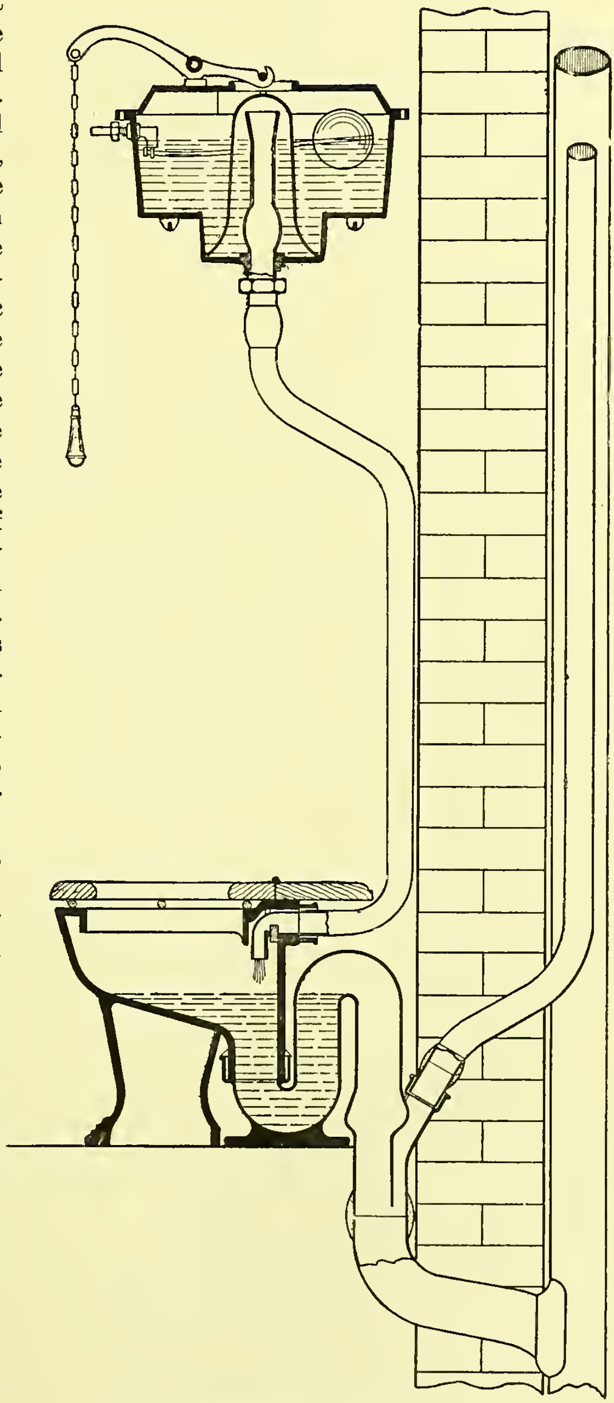


Fig. 554.—Siphonic Closet with Deep-seal Trap

formation of a vacuum at B. This pipe D must be carried up nearly or quite as high as the bottom of the flushing tank. For public urinals it can be finished inside the building, but for private houses it must be turned out through the wall into the external air as shown.

In fig. 554 is illustrated quite a **different type of siphonic closet**. The pan is of vitro-porcelain, and one trap only is attached, which is of lead, and has a deep seal of 8 in. The air is exhausted in a totally different fashion, the siphonage being produced by the direct action of the water from the service pipe. The closet and the special flushing cistern, which must be used, are shown in section in the illustration. As will be seen, the water from the cistern is discharged from the flush pipe in the form of a powerful jet, which is directed into the standing water in such a fashion as to send a "spurt" of water through the trap and over the weir. In falling down the latter, it drives the air before it and forces some up the trap-ventilating pipe, attached in the position indicated. By this means a vacuum is caused in the upper portion of the long leg, permitting the contents of the basin to be forced out.

For this apparatus it is claimed, in addition to the deep seal, that it is simple in construction; proof against unsealing by throwing in a pail of slops; perfectly flushed by 2 gal. of water, as all the flush passes through the trap; and that it possesses a very large water area. The only drawback is that it is noisy in action.

An amended form of this closet is arranged so that on the throwing in of a pail of slops the siphonic action is started, and at the same time the flushing cistern is automatically started by a patent arrangement connecting the flush pipe and the long leg of the siphon.

Still another method of starting the siphonic action is illustrated in connection with the latrine shown in fig. 567, which is also applied to ordinary water closets. In this case two traps are required, as in the closet shown in fig. 553, but without the puff pipe. From the top of the long leg of the siphon a small pipe is carried up and turned over into the upper portion of the flush pipe, as shown by the dotted lines. On starting the cistern, the water, in falling down the flush pipe, drags with it the air contained in the small pipe, thereby releasing the pressure on the outgo side of the water in the trough, and forming a partial vacuum in the upper portion of the leg, the result being that the contents of the basin or latrine are pushed out by the pressure exerted on the surface of the water in the trough. For this closet also it is claimed as an advantage that the whole contents of the flushing cistern pass through the closet basin.

There is no doubt that these siphonic closets possess some of the merits of the valve closet without the corresponding disadvantages, and apparatus of this type will probably be largely developed during the next few years.

All these types are very quick in discharge, and they possess respectively an exposed water area in the basin of 12 in. by 10 in., 13½ in. by 11 in., and 10 in. by 8½ in.

Safes.[1]—With the exception of the pedestal form, it is advisable to provide a lead safe to all valve closets to catch the splashings, unless

[1] See Vol. I, pp. 165 to 168.

the apparatus is fixed on a tiled or impervious floor, and particularly is this required when the apparatus is used also as a slop closet, as water-tight joints between the top of the basin and the under side of the seat—even where a table top is provided—cannot be depended upon, owing to the carelessness frequently displayed in the fitting of the woodwork.

The safe should be formed of 4- to 6-lb. lead, at least 4 in. in height, and have a waste pipe attached discharging into the external air, a hinged flap of brass or copper being fixed at the outer end. On no account should the waste be allowed to connect with a soil pipe or with a waste pipe from any other fitting. The size required for the waste pipe varies from a minimum of $1\frac{1}{4}$ in. to a maximum of 2 in., and a suitable metal grating to keep out large extraneous matters should be fixed over the inlet. It is unnecessary to provide safes to pedestal closets, except where the apparatus is used as a urinal, or where the floor is of a pervious character. In these instances it is advantageous to cover the floor under and immediately contiguous to the apparatus with sheet lead, but no waste pipe should be connected, as the constant dripping from the waste pipe of splashings of urine is more often than not a source of nuisance. It is best to have the safe maintained in a clean state by hand. Instead of a lead safe, marble or glazed-ware floor slabs slightly dished can be usefully employed.

From a purely sanitary standpoint **seat enclosures** are undesirable, as they provide a receptacle for dust, impede the free movement of the air about the apparatus, and make it difficult to cleanse the surroundings properly. With pedestal closets they are needless, and are, in fact, only required in the case of certain valve closets. For all closets reserved for the use of women, a seat extending the entire width of the apartment is, however, more acceptable, and if the riser is omitted, and the seat is hinged, no reasonable objection can be raised.

Where enclosures are provided, the riser seat and flap should be made of hardwood, well fitted and hinged, so as to render every part of the apparatus accessible; and the exposed surfaces should be made impermeable by the application of French polish or oil paint.

Lift-up Seats.—All that is wanted for pedestal closets is a hinged seat (with a flap if desired), either of the lift-up kind or fitted with a balance which raises the seat automatically upon its being vacated. Brass side hinges and rubber buffers should be employed, and the seat should be cross-lined to prevent warping, and all surfaces French-polished, varnished, or painted.

To carry the seat, it is usual to fix brackets of cast iron or gun metal to the rear wall or the floor. The first position is preferable, as it leaves the floor clear and imposes no obstruction to its being kept clean. The brackets should be as plain as possible, and well pinned into the wall.

Many closets are, however, now made sufficiently strong to make the use of brackets unnecessary. The seats are either made with a back and skirting for fixing to the wall or are attached by nuts and bolts to the specially extended top of the pedestal itself, as illustrated in the plan in fig. 549.

Seat Rings.—In schools, factories, prisons, asylums, and hospitals, movable wooden seats are gradually being displaced in favour of seat rings made of teak or other hard wood, screwed to the top of the basin (which is of special make), as illustrated in fig. 555. An excellent seat for hospital use is the metallo-vulcanite seat (fig. 556), which consists of a stamped steel lining covered on both sides with vulcanite, and fitted to the rim and bolted to the back of the apparatus. Having no corners or angles to accumulate dirt, these rings can be maintained in a clean condition with the smallest amount of attention. Much difficulty has been experienced in making a water-closet seat that will be impervious to moisture and yet comfortable to use, and in these respects the metallo-vulcanite seat rings approach as near to perfection as any yet produced.

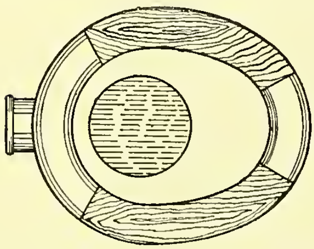


Fig. 555.—Wood Seat Ring

Flushing Cisterns and Valves.—The use of special flushing cisterns for water closets is now insisted upon by nearly all sanitary authorities, with the object of entirely separating the storage cisterns, which supply drinking water, from the water-closet apparatus, so as to avoid any risk of contamination. Where the supply of water both for drinking and flushing purposes is obtained from the same cistern, any direct connection, such as the under-seat valve used in connection with valve closets, or a flush pipe fitted with a plug cock or screw-down tap, is prohibited. It will thus be seen that, even for modern valve closets—unless they are supplied from a cistern devoted solely to flushing water closets or urinals,—an intermediate cistern must be fixed between the storage tank and the water-closet apparatus.

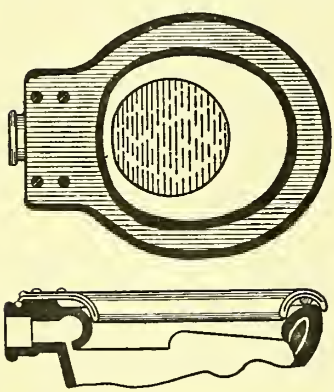


Fig. 556.—Metallo-vulcanite Seat Rings

Some water companies also insist upon a water-waste preventing apparatus for closets of the valve type. If it can possibly be avoided, the waste-preventer should not take the form of a cistern, as the wires required for working this get out of order.

Under-seat valves for this kind of closet vary in size, according to the head of water available, from 1 to 1½ in. The valves are of two kinds, the first providing an unlimited flush and the second being a waste-preventing valve that allows only a stated quantity of water to pass through. The former is prohibited by nearly all water companies. If the latter is used, it should be fitted with an after-flush attachment; otherwise if the valve is kept open too long there is a risk of the basin being left unprovided with water. The action mostly employed is a lift-up handle, but occasionally a treadle action is fixed.

Wash-down and siphonic closets are now habitually flushed by independent water-waste preventers fixed above the appliance. These are

small cisterns, containing from 2 to 3 gal. of water, and are worked on two distinct principles—the valve and the siphon.

Fig. 557 illustrates a single-valve cistern, fitted simply with a ball valve to control the supply and a lift-up valve over the inlet to the flush pipe. It is not a waste preventer, as the water will run all the time the handle is held down, and for this reason it is objected to by many water companies.

Some type of **syphonic cistern** is

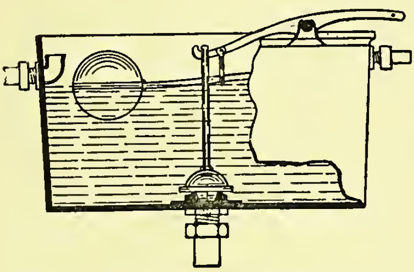


Fig. 557.—Flushing Cistern with Single Valve

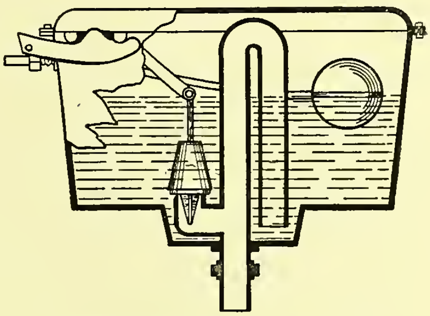


Fig. 558.—Siphonic Cistern with Valve

now almost universally adopted, but there are many methods of starting the siphonic action. In fig. 558 the water is set in motion by the lifting of the valve, which allows the water to fall down the flush pipe. If the valve is kept open by holding the pull handle, the action of the cistern is almost identical with that of the single-valve cistern already described; but if the handle is released the siphon is brought into operation by the water discharged through the valve while it was open. As leakage may occur through the submerged valve, many water companies prohibit cisterns of this type.

In fig. 559 is shown a cistern patented by H. Pontifex & Sons, which is in reality a water waste preventer. The end of the siphon is in the form of a drum, in which is fitted a metal disc connected to the flushing lever; when the chain is pulled, the disc is raised and a quantity of water is forced over the bend of the siphon pipe, thus creating a vacuum which continues to draw water down the flush pipe. Before the cistern is quite emptied a metal float opens an air inlet to the siphon, and the action is thus stopped before the objectionable gurgling sounds commonly heard can commence.

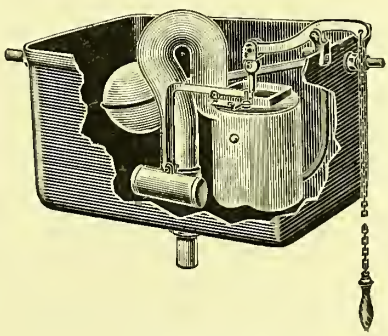


Fig. 559.—Pontifex's "Nosound" Water Waste Preventer

The siphon cistern shown in fig. 554 is fitted with a dome, standing over a vertical tube directly above the flush pipe, and the siphonic action is started by lifting up and letting fall the dome, which in descending displaces a quantity of the water and forces it over the vertical tube into

the flush pipe. Owing to the weight of the dome these cisterns are noisy in action, but the noise can be reduced by means of rubber buffers.

Other siphonic cisterns are operated by a metal plunger or disc, working in a vertical or horizontal cylinder, by which a quantity of water is forced into the long leg of the siphon for the purpose of starting the action.

To obtain sufficient pressure to flush out the contents of the closet basin, water-waste preventers of ordinary types must be fixed several feet above the apparatus, a distance of 5 ft. — unless impracticable — being regarded as the minimum.

A mistake that is frequently made is in the **size of the ball valve** supplying the cisterns. Many of them are fitted with a $\frac{3}{8}$-in. valve, and consequently, where the head of water is only a few feet, the cisterns take several minutes to refill. The ball valve should never be less than $\frac{1}{2}$ in., and where the head of water is less than 10 ft. a $\frac{3}{4}$-in. valve is requisite, as the valve used should be able to recharge the cistern—particularly where the convenience is in great demand—in one to one and a half minute.

To lessen the noise produced in the filling of the cistern, a **silencer**, which generally takes the form of a tube connected to the valve and carried down close to the bottom of the cistern, should be attached.

To all cisterns **an overflow** must be fitted, which must, according to the regulations of water companies, take the form of a warning pipe—that is, a pipe with an open end, discharging in such a position as to give immediate notice of an overflow. The size of the overflow depends upon the size of the ball valve and the pressure of the water, but it should never be less than $\frac{3}{4}$ in. in diameter, and must discharge into the external air. The pipe will convey the water away more rapidly if the inlet is shaped as shown in fig. 557, than if the usual straight connection is made.

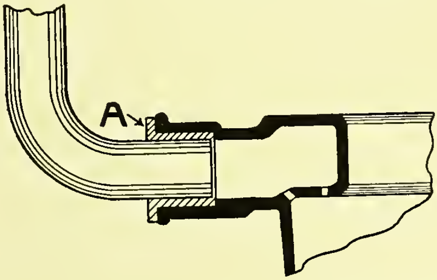
The materials used in the manufacture of these cisterns include glass, marble, pottery, cast iron, and wood with a lead or copper lining. The use of the two first mentioned is generally confined to public lavatories, while the last two are in common use. If cast iron is used, it should always be galvanized or coated with a glass enamel. Lead-lined cisterns are to be preferred for exposed positions, as they withstand the effects of frost better than iron.

Flush pipes for connecting the water-waste preventer with the arm of the basin can be obtained in iron, brass, copper, or lead. Except for positions where exceedingly rough usage is unavoidable, or where a more valuable metal would, perhaps, be stolen, iron should not be selected for this work, as it is rough inside. Sharp elbows should in any case be avoided, as they increase the friction and retard the flow of the water. Brass and copper tubing are both good materials, but the original cost, together with the expense incurred in fitting the pipes to special positions, prohibits, as a rule, their use except for the best class of work. Lead is mostly used for flush pipes, for which purpose its adaptability renders it very convenient. Lead pipes $1\frac{1}{4}$ in. in diameter should weigh at least 9 lb., and $1\frac{1}{2}$-in. pipes $10\frac{1}{2}$ lb., per yard.

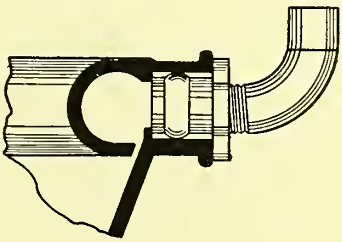
The minimum size for flush pipes is now generally accepted as $1\frac{1}{4}$ in., a size which is stipulated in many districts, not only for the flush pipe, but also for the union connecting it with the waste-preventer. This diameter is satisfactory where a minimum head of 5 ft. can be obtained, but where this is impossible the diameter of the pipe should be increased to $1\frac{1}{2}$ in., or even 2 in.

Fixing.—Flush pipes should be securely fixed by means of soldered lead tacks or metal clips, and have as few bends as practicable, those that are necessary being of an easy character. Knuckle joints are objectionable, as they impede the flow of the water.

Connection with Basin.—The joint between the flush pipe and the arm of the basin can be made in a number of ways, among which are various screwed connecting pieces, rubber cones screwed or fixed with copper wire, screwed expanding connectors on the same principle as a drain-



No. 1



No. 2

Fig. 560.—Flush-pipe Connections

stopper, and brass ferrules with asbestos or rubber packing or fitted with a rubber ring. No. 1, fig. 560, illustrates an improved rubber cone at A, and No. 2 shows a rubber expansion joint. Where iron flush pipes are used, the joint is often made with Portland cement.

Valve closets are mostly flushed by **an under-seat apparatus**, actuated by the pulling up of a handle in the seat, which liberates the contents of the basin, and at the same time opens a supply valve, letting in a quantity of water to flush and recharge the basin. Occasionally a treadle valve is fitted to the apparatus in lieu of the pull-up handle. To permit of the basin being recharged after the handle is dropped, a regulator, generally of the "bellows" type, is attached, which governs the valve and prevents it from closing too quickly.

Instead of an under-seat valve a **flushing cistern** can be provided, in which case the cistern apparatus and the handle in the seat are connected by a series of wires.

Wash-down and siphonic closets are operated by **the water-waste preventer** alone, which is acted upon in the greatest number of instances by a chain or rod pull, affixed to a lever in the cistern, as in fig. 554.

An excellent arrangement for use, not only under ordinary circumstances, but particularly in asylums and prisons, where all furniture likely to be misapplied must be dispensed with, is the press-button method of starting the action of siphonic-flushing cisterns, as shown in

fig. 561. The cistern is fitted with a brass or copper tube inserted in the inlet of the siphon. At the bottom of the tube a push valve, as illustrated in the enlarged section, is affixed. As the cistern fills, the tube becomes charged with water, and on pressing the valve the rubber diaphragm A is pushed back, forcing the water up the tube and sending a jet over the bend of the siphon. In falling, the water displaces the air in the long leg of the siphon and starts the action.

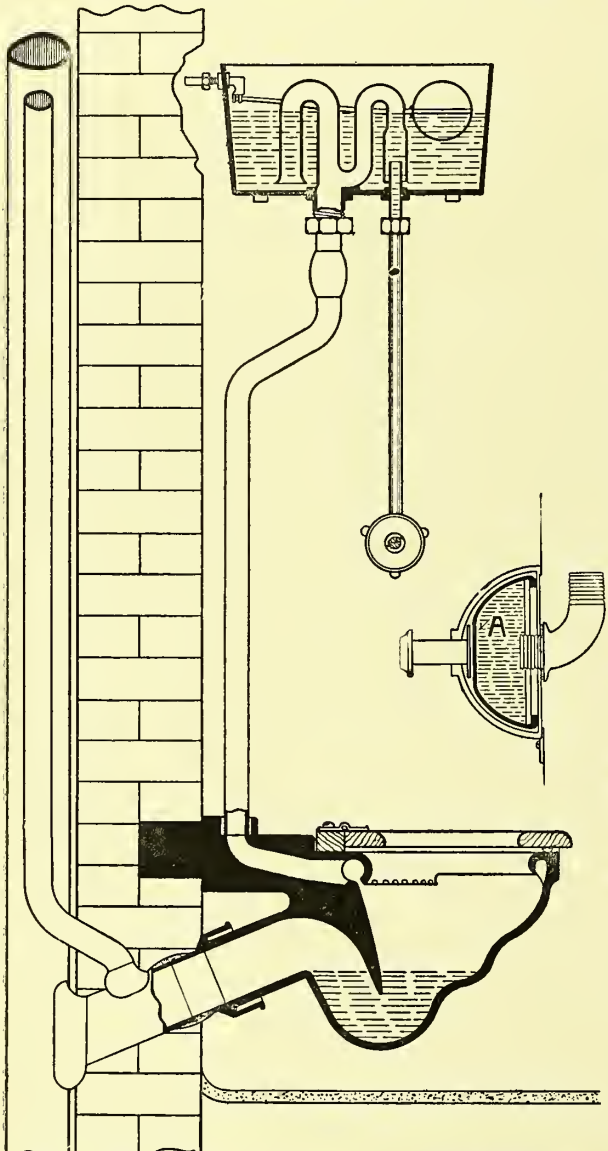


Fig. 561.—Corbel Water Closet and Press-button Siphonic Flushing Cistern

A somewhat similar push valve, but of pneumatic action, which forces a jet of water into the siphon from the cistern, has also been lately introduced.

For schools and factories, or any place where there is likely to be negligence in the use of the convenience, apparatus worked by seat or door action are necessities. Siphon cisterns are essential when worked by either of these modes, as the action both of the seat and the door is momentary. In both cases the lever in the cistern is acted upon by a wire or rod connected to the seat or door. When the former action is required, the seat is fitted with a counterpoise, which permits it to assume an upright position on being vacated, and at the same time pulls down the rod or wire attached to the cistern lever, thus setting the siphon in motion. With the door action the lever is acted upon by the opening of the closet door. The great disadvantage of these automatic arrangements is the ease with which they are deranged.

The quantity of water required for flushing water closets, and floating their contents through the drain into the sewer, has often been a source of controversy. Most sanitarians claim that a minimum of 3 gal. is essential, but water companies and their engineers maintain that 2 gal. are ample for the purpose. Although a 2-gal. flush may be adequate in some instances, there is not the slightest doubt that a 3-gal. flush is more efficient, and should be secured wherever possible. In districts where the flush is limited to 2 gal. special care should be given to the selection of the closet and cistern, as some types can be satisfactorily worked by a flush which would be quite inadequate to maintain other forms in a clean state.

Combination or "Low-down" Closets.—Owing to the objections urged by many people against wash-down and siphonic closets on account of the noisy action of the high water-waste preventer, and the multiplication of pipes, with the resultant unsightliness, wash-down closets with the water-waste preventer fixed on the seat are now made, and are known as "combination", "compact", or "low-down" closets. This form of water closet admirably fulfils its purpose. It is quick and silent in action, and neat and compact in appearance. The obstacle of the loss of head occasioned by the abolition of the long flush pipe is overcome by the enlargement of the short connecting piece between the cistern and the basin, as well as the inlet arm of the latter, to an internal diameter of 2 in. or more. Valve or siphon flushing cisterns, fitted with a full-way ball valve and silencer, and operated by a pull or lever, are supplied with these closets.

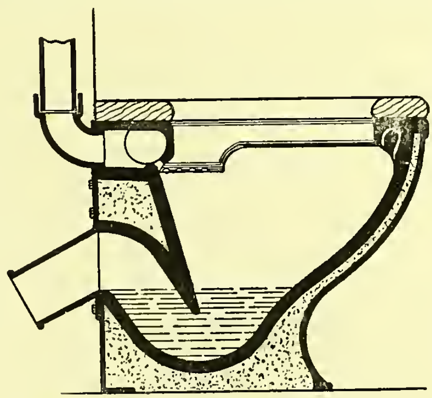


Fig. 562.—Strong Water Closet for Prisons, &c.

Water Closets for Special Positions.—For prisons and workhouses wash-down closets are preferred, and these can be obtained of special make and strength, the fireclay in some instances being 1 in. in thickness, which practically renders it unbreakable. A very strong fitting, intended for prison use in particular, is illustrated in fig. 562. It consists of a fireclay pan and trap, fitted into a cast-iron lining, the intervening space being filled with Portland cement. The seat is screwed to the top of the closet, and the trap is provided with an iron outgo. The flushing cistern should either be fixed outside the cell or apartment, and be accessible only to the attendants, or, if fixed in the apartment, be of such a form as to render the misapplication of any of the parts impracticable.

"Corbel" and "bracket" water closets were designed primarily for hospitals and public institutions, but are useful also in dwelling houses, especially where used as urinals. The corbel closet (fig. 561) is made in one piece of strong enamelled fireclay, but can also be had with a lead trap. It has a solid projecting back for building into the wall, and when fixed

is entirely self-supporting. The weight of the bracket closet, as its name denotes, is carried by two brackets let into the wall. The great advantage of these types is the fixing of the apparatus clear of the floor, thus abolishing the small angles and recesses for the accumulation of filth, and enabling the floor, as well as the under side of the apparatus, to be kept thoroughly clean.

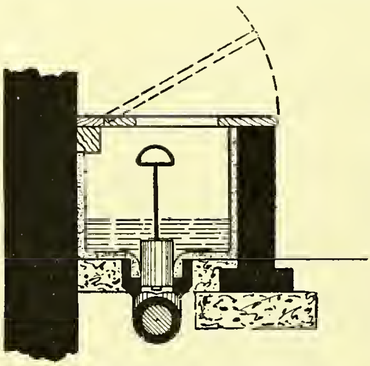


Fig. 563.—Insanitary Trough Closet

Closets for Schools, Factories, &c.— In one form or another **the trough closet** has reigned for a long period, and still maintains its existence, notwithstanding the march of sanitation. Fig. 563 shows a section of the square brick trough which is still occasionally discovered in factories and schools. The trough is usually provided with an outlet discharging either directly or through a trap into the drain, and fitted with a wooden plug, as shown. A flushing cistern, or more frequently a service pipe fitted with a stop cock, discharges into the trough. The latter is supposed to be charged with a sufficient quantity of water to receive the solid matters; but, either owing to the want of attention or to the wooden plug fitted in the drain inlet being defective, the water is permitted to run away into the drain, leaving the trough empty except for the solid matters. Under these conditions the trough closet degenerates into something worse than a common privy,

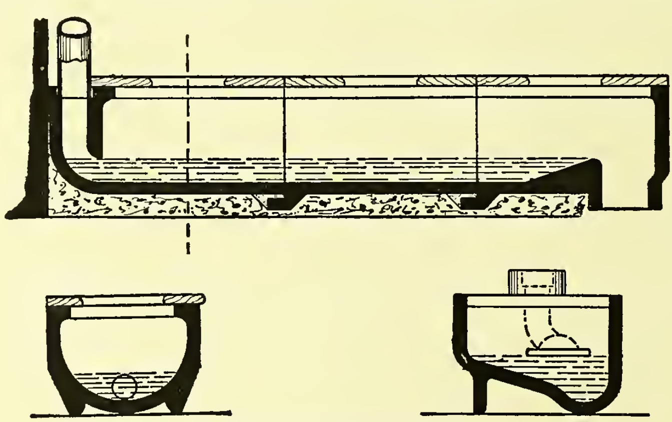


Fig. 564.—Improved Trough Closets

for the latter is generally situated some distance from the premises, whereas the trough closet is not infrequently fixed in, or in close proximity to, occupied buildings.

Improved trough closets are illustrated in longitudinal and cross section in fig. 564. In each case the trough is constructed of glazed fireclay, and its configuration is such that a quantity of water is always retained in it. A trap is generally provided between the outlet and the drain, and a

flushing tank for cleansing purposes. Another variety (fig. 565) is fitted with a flushing rim, which must be regarded as an improvement.

The principal objections to trough closets are: (*a*) a large fouling area and the impossibility of properly cleansing the internal surface of the trough; (*b*) the freedom with which offensive smells can pass from one seat opening to another; (*c*) the danger of infection from the deposited stools, which frequently remain uncovered; and (*d*) the intermittency of the flush.

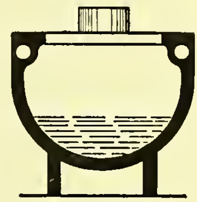


Fig. 565.—Trough Closet with Flushing Rim

It is sometimes argued that, having regard to the class of person using the convenience, ordinary water closets would be constantly blocked, owing to the use of unsuitable materials, such as straw, for sanitary purposes, while the troughs illustrated cannot be readily choked, as they are provided with large outlets, and also require a smaller amount of water for flushing purposes, thus effecting a great saving over ordinary water closets.

Under special circumstances, such as those found in barracks and similar premises, the provision of trough closets may possibly be justified, but in factories ordinary water closets are very successful in their action, are capable of being maintained in a cleaner state, and are less provocative of nuisance than trough closets. In schools the use of trough closets is indefensible.

Where a range of closets is considered to be absolutely necessary, preference should be given to the salt-glazed stoneware latrine, illustrated in fig. 566, where the internal area is reduced and basins of a particular kind are provided. The connecting pipe is trapped, emptied by means of siphonic action in the same manner as the water closet shown in fig. 553, and flushed by an automatic flushing tank, which discharges at the end of the range.

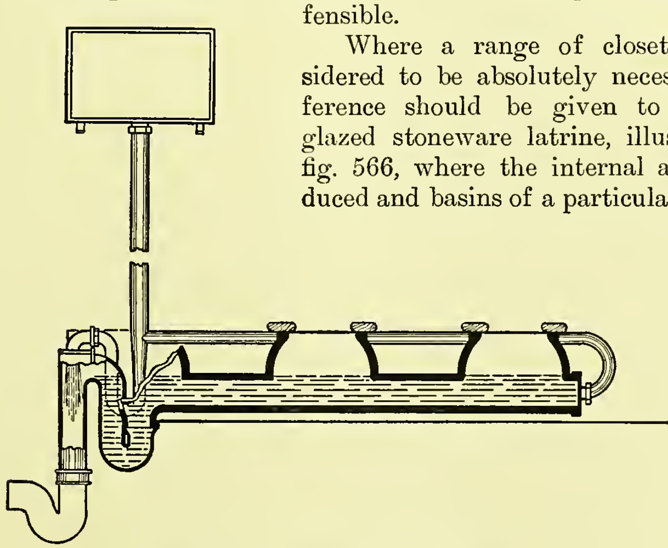


Fig. 566.—Glazed Stoneware Trough Closet

The isolated closet range of glazed stoneware (fig. 567) is a distinct advance and is capable of taking the place of the trough pattern in the majority of instances. The separate basins, which are fitted with flushing rims, discharge into one common pipe, so raised at the outlet end as to

retain a fairly large body of water in the basins to receive the fæcal matter. A trap with a long leg is attached, an air pipe being fitted to the crown, and connected to the flush pipe as shown, for the purpose of starting the siphonic action, by which the contents are removed. The separated basins prevent the passage of foul emanations from one seat hole to those adjoining, but the nuisance arising from the stools is sometimes accentuated as the solid matters may become suspended at the bottom of the basins.

It is well to repeat that troughs and latrines are undesirable, and their selection can only be admitted on the grounds of expediency, as even the most up-to-date appliance fails to comply with the now generally accepted

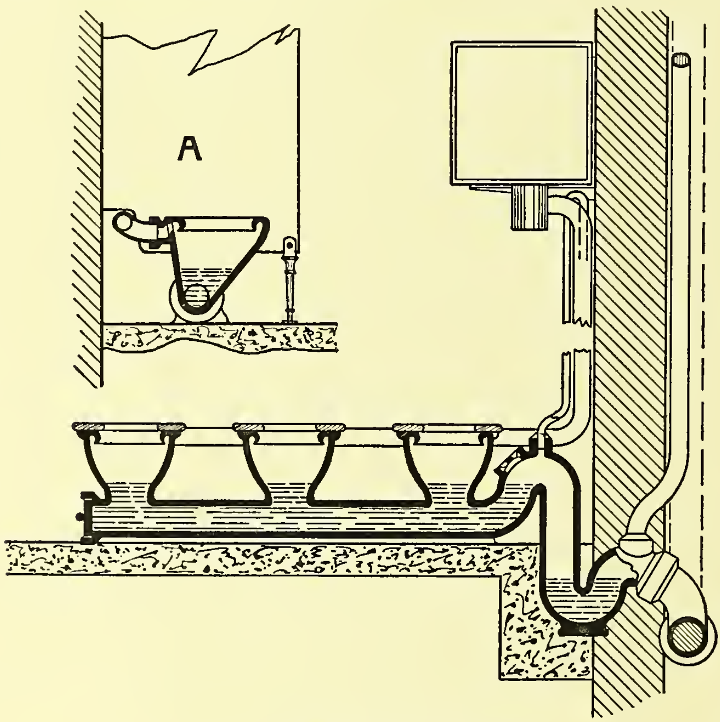


Fig. 567.—Isolated Closet Range

view, that the apparatus provided should be of such a form as to be flushed after each user.

Automatic Flushing Tanks.—The troughs and latrines illustrated are designed to be flushed by means of automatic tanks. With the exception of figs. 565 and 567, all the troughs shown are flushed solely through the flush pipe attached to the end of the trough farthest from the drain inlet. In the isolated range illustrated in fig. 567 the water passes through the several basins into the trough.

Flush tanks for trough closets, latrines, and closet ranges with isolated basins should always be automatic in action. The tanks are usually made of iron, either painted or galvanized, and should be fixed on brackets or other strong supports at least 6 ft. above the floor level. The size of the

flush tank depends upon the number of persons that the range accommodates, but at least 5 gal. should be allowed for each basin.

In most flushing tanks worked by a siphon, a reverse-action ball valve is essential, as one of the ordinary kind would allow the water to dribble through the flush pipe without having any effect upon the siphon. A reverse-action valve starts with a dribble, and as the cistern fills the valve is opened more and more until the valve runs full bore, and the water is forced rapidly over the lip of the siphon, thus starting the discharge.

There are many kinds of automatic flushing tanks designed for work of this character. Suffice it to illustrate one new form (fig. 568), which consists of the ordinary annular siphon fitted with a patent arrangement for absolutely ensuring the automatic discharge. A ball valve is not essential; the tank can be charged from a "pet" or stop cock, and will work satisfactorily with a drop-by-drop supply. The patent action consists of two interlocking balls, the lever of one being attached to the dome of the siphon. As the water rises in the tank, the flat-topped ball rises with it, and on the water reaching a certain height (above the top of the siphon pipe), this ball releases the other, which immediately springs to the surface, carrying the dome with it. During the filling of the tank, the air in the leg of the siphon has become compressed as usual. By the raising of the dome a partial vacuum is caused in the confined space, and in the attempt to recharge this vacuum the contents of the cistern are pushed through the siphon.

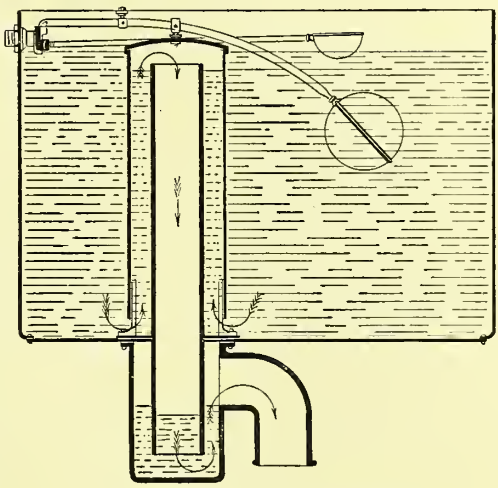


Fig. 568.—Automatic Flushing Tank

Size of Flush Pipes, &c.—For ranges of the kind shown in fig. 567, and not exceeding six closets, a painted or galvanized iron or a lead flush pipe, 3 in. in diameter, with reduced branches varying from 2 in. to 1½ in. to the different flushing-arm inlets, and a 4-in. horizontal pipe trough with a 5-in. trap are required.

The frequency of the flush depends solely upon the work that the closet has to perform. In some cases a discharge once every few hours is sufficient, while in many others the interval should not exceed thirty minutes. This latter period is the one that for ordinary purposes should be counted upon.

Seats.—In the older form of closet a wooden seat is fixed directly on to the rim of the trough, as in fig. 569; but in the modern examples, shown in figs. 566 and 567, seat rings only are used.

Screens.—Many existing ranges of closets are used in common, there being no division between the seat holes. In other cases partitions of the

same width as the seat are provided, as at A, fig. 569, whilst others have partitions as shown at B. Partitions or screens are generally fixed about 2 ft. 3 in. apart. Wooden partitions are inferior to the cast-iron screen illustrated at A, fig. 567, which is 2 ft. 6 in. wide by 5 ft. high, and stands clear of the floor as shown. These iron screens should be either metallic-, glass-, or vitreous-enamelled. The by-laws in London require a proper door fitted with fastenings to be provided.

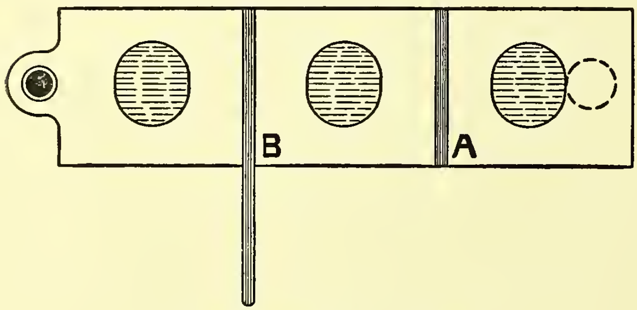


Fig. 569.—Partitions between Latrines

For the special use of infants and young children various **dwarf wash-down closets** are now made, the seat being only 1 ft. from the floor.

Waste-water Closets.—A form of closet not hitherto mentioned is that known as a "waste-water closet", which utilizes the waste water from the various sanitary fittings as a flushing agent. In general it consists of a vertical shaft, provided with a seat in the same way as an ordinary water closet. The portion of the trough below the level of the floor is enlarged to receive a "tipper", hung slightly out of the centre, into which the waste pipe from the scullery sink or other fitting is made to discharge. The "tipper" acts as a depository for the fæcal matter from the water closet, and when full overbalances, thus discharging the contents into the drain.

In an improved type, instead of the vertical shaft, a trapped pedestal water closet is fixed, into the pan of which a waste pipe is brought from the chamber where the tipper is situated.

The only argument in favour of this form of convenience is the smaller amount of water used as compared with ordinary water closets. On the other hand, particularly where a vertical shaft is provided, the sides are quickly fouled and the appliance becomes most offensive. A closet of this kind is more objectionable than a trough closet or latrine, and is much inferior to an earth closet, which could be used with greater advantage and decidedly less nuisance under similar circumstances.

CHAPTER VII

SOIL PIPES

Soil Pipes are generally understood as being pipes fixed above the ground (as distinguished from drains, *i.e.* pipes under the ground), and provided for the conveyance of solid and liquid matters from water closets, slop sinks, and urinals, and in accordance with the by-laws in force in many districts the use of such pipes is restricted to the carriage of waste

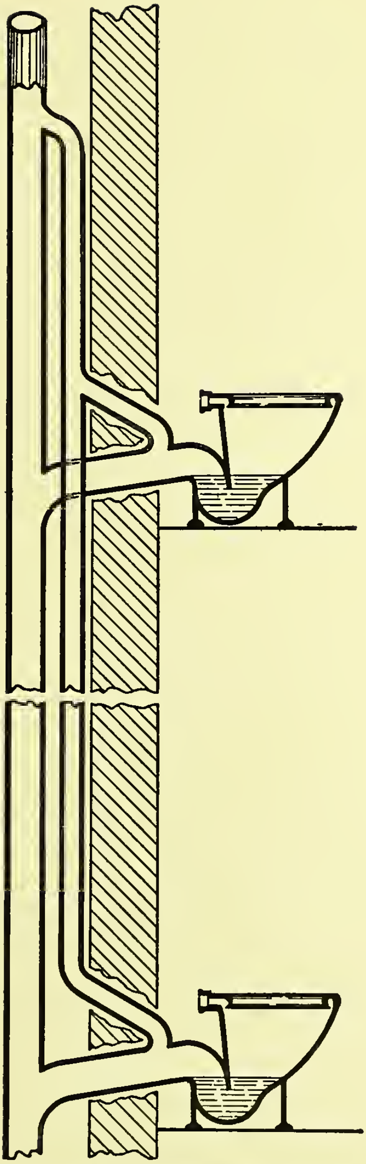


Fig. 570.—Soil Pipe for Single Water Closets on Different Floors

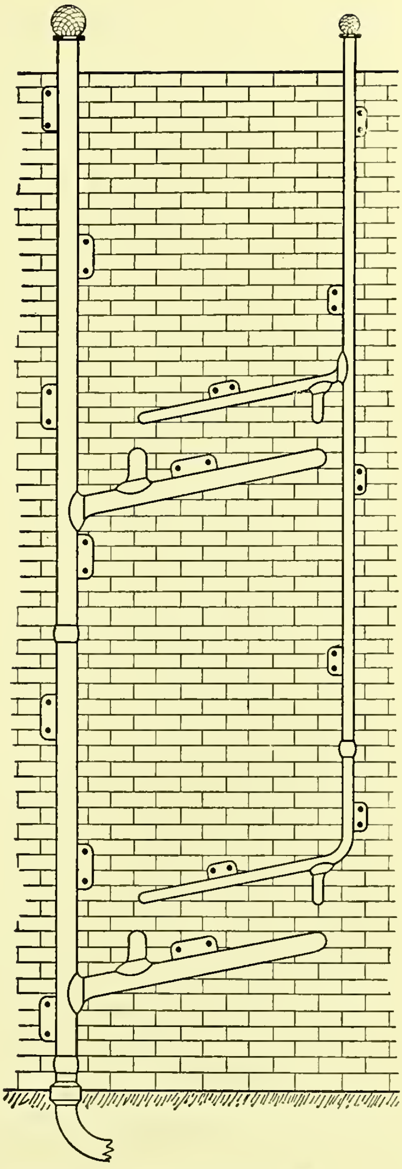


Fig. 571.—Soil Pipe for Ranges of Water Closets on Different Floors

matters from these fittings, it being an infringement to connect rainwater pipes, or the waste pipes of sinks, lavatories, and baths to a soil pipe.

Soil pipes are sometimes used as **rainwater conductors**, but for several reasons this is objectionable. Eaves gutters are in many instances within a few inches of bedroom windows, and if the soil and rainwater pipe is one, foul gases are discharged in a position that will render their entry into occupied rooms highly probable. During rainy weather the free use of the

pipe for ventilating purposes is also impeded, and there is a risk of the falling water siphoning the seals of the communicating traps.

The proper position for soil pipes is outside the external walls of the building, where, in the event of a defect occurring, the danger of an escape of foul gases into the building is minimized, and more complete diffusion is possible. Most codes of by-laws insist, where practicable, upon an external position. If fixed inside the premises, the pipes should be easily accessible. Fixing in a "chase" should be avoided.

Arrangement.—In public buildings a number of fittings are often provided on a particular floor, but in private houses the more general arrangement is to fix one water closet on each floor, thus forming a tier of fittings. Fig. 570 illustrates two water closets on different floors connected with a 4-in. ventilated soil pipe provided with 2-in. trap-ventilating pipes, the usual method of connecting the latter to the soil pipe above the topmost fitting being followed. In fig. 571 are shown in elevation the soil and ventilating pipes from two ranges of water closets fixed on different floors, the trap-ventilating pipes in this instance being carried up to the same height as the main-ventilating pipe. These examples illustrate the alternative methods of arranging the ventilating pipes as stipulated in many districts.

The materials employed for soil pipes are now practically limited to lead and iron in various forms. Zinc is almost entirely discarded owing to its fragility and the ease with which it is corroded; and the difficulty of securely fixing stoneware and its liability to fracture militate against its adoption. In London soil pipes fixed inside buildings must be of drawn lead, but for external positions either lead or iron may be used.

Lead soil pipes are now almost universally made of drawn lead, which is far superior to the soldered-seam pipes in vogue years ago. The standard length is 10 ft.; the strength varies from 5 to 8 lb. per superficial foot; and the sizes from 2½ to 6 in. in diameter. Pipes of greater strength than 8 lb. can also be obtained, but are not, as a rule, stocked by manufacturers. The metal should be the best pig lead, and of equal thickness throughout.

The following table shows the weight of lead pipes and the comparative strength as compared with sheet lead:—

Lead Soil Pipe in 10-ft. Lengths.

Diameter of Pipe in Inches.	Sheet Lead.					
	5 lb.	5½ lb.	6 lb.	6½ lb.	7 lb.	8 lb.
	Weight per 10-ft. Length in pounds.					
2½	34	38	41	45	48	55
3	41	45	49	53	57	66
3½	47	52	57	62	66	76
4	54	59	65	70	76	87
4½	—	66	73	79	85	97
5	—	—	—	—	94	108
6	—	—	—	—	112	129

In London lead soil pipes must be at least of the undermentioned weight per 10-ft. length, a weight approximating to 7-lb. sheet lead:—3½-in., 65 lb.; 4-in., 74 lb.; 5-in., 92 lb.; and 6-in., 110 lb.

For reasons indicated when considering pipes and traps, lead soil pipes are preferable to any other kind. Properly arranged, fixed, and ventilated, they are practically indestructible. One great advantage of lead is its adaptability to any position, in which respect it is much superior to iron, as the latter necessitates special castings unless certain angles are rigidly adhered to. A drawback to the use of lead if the pipe is fixed in an exposed position is the ease with which it is bruised and damaged, and a liability to twist and break under changes of temperature. Where the pipe is likely to be knocked, protection should be afforded either by slipping the bottom length through a piece of iron pipe of larger diameter, or by encasing it in sheet iron, as in fig. 572. To obviate damage by atmospheric conditions, the pipe should be fixed in a position, if possible, where it is not exposed to the direct rays of the sun.

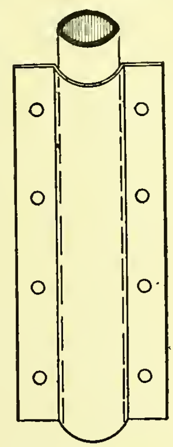


Fig. 572. — Lead Soil Pipe protected by Sheet Iron

On account of superior strength and cheapness, **cast-iron pipes** are now largely employed; but they should never be used in an uncoated form. For the internal surface of the pipe actually in use for the conveyance of sewage, a coating is immaterial, as a thin film of slime is soon deposited, which has the effect of preserving the metal; but the portion in use for ventilating purposes only and the whole external surface are constantly subject to the influence of the atmosphere, with the result that rusting takes place. Cast-iron pipes for use as soil pipes are usually made in 6-ft. lengths; but 9-ft. lengths, as well as short pieces, can also be obtained. The thickness and weight of iron pipes are in London specified as follows:—

Thickness and Weight of Iron Soil Pipe.

Diameter of Pipe in Inches.	Thickness of Metal.	Weight per 6-ft. Length (including socket and beaded spigot or flanges, the socket not to be less than ¼ in. thick).
3½	$\frac{3}{16}$ in.	Not less than 48 lb.
4	$\frac{3}{16}$ ”	” ” ” 54 ”
5	¼ ”	” ” ” 69 ”
6	¼ ”	” ” ” 84 ”

Most manufacturers now make pipes approximating to the above, in addition to lighter and heavier types. Under all conditions the pipes should be of sufficient strength to enable the joints to be caulked with molten metallic lead. Iron bends and junctions are commonly made to angles ranging from 90° to 157½°.

Joints.—The methods of connecting lengths of soil pipe can be classified

under three heads: (1) Wiped or fused joints, (2) caulked or compressed joints, and (3) mechanical joints.

Wiped Joints (figs. 576 and 577) are the most perfect, but their use is restricted to lead pipes. In many districts this form of joint is obligatory for lead soil pipes, as in London. Joints made with the blowpipe or copper bit are not allowed, as they are far less satisfactory.

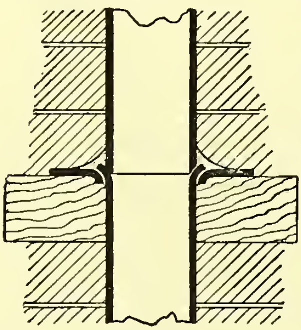


Fig. 573.—Block or Flange Joint for Lead Soil Pipe

Round wiped joints are nearly always used where the pipes are fixed on the face of a wall, but if fixed in a chase, **the block, taft, or flange joint** (fig. 573) is employed. For these joints specially prepared wooden blocks should be built into the wall and a lead collar fitted to the pipe, as shown, the ends of the pipes and the collar being united by the flange joint. For additional support a collar or flange should be wiped on to every length midway between the joints.

The astragal joint (fig. 574) can be applied to pipes without indicating so plainly the fact that the pipe is a carrier of fæcal matter. Certainly the plain appearance of the ordinary soil pipe can be relieved by the use of this joint, but the strength, which is of primary importance, is inferior to that of the round wiped type.

Compressed or caulked joints are used for iron soil pipes and for connecting brass or copper thimbles or sockets to iron pipes, the joints being made with various materials, including molten metallic lead, lead ribbon, Portland cement, red and white lead, and rust cement. *Rust cement* consists of an admixture of clean iron borings, flour of sulphur, and sal-ammoniac. The materials are pressed into the annular space between the socket and spigot, where the borings are oxidized and combine with the iron. In this joint the iron pipes must be uncoated, as the presence of a tarry or greasy compound prevents the necessary oxidation. *A mixture of red and white lead* applied in a mastic condition is often used for cheap work, but it is unsuitable, owing to the absorption of oxygen which takes place, rendering the material brittle. *Portland cement* is unreliable when used in this type of joint, as it does not expand in the same ratio as iron and brass. As a result the most brittle material, *i.e.* the cement, is easily cracked.

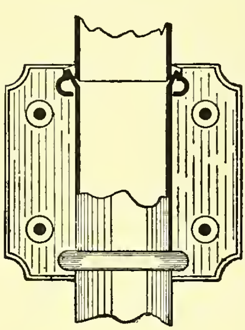


Fig. 574.—Astragal Joint

Occasionally *lead ribbon or tape* is used, being rammed into the joint with a staving tool. It is, however, uncertain, and inferior to molten lead. Modern practice does not countenance the use of any material except *molten metallic lead*, which makes the best type of caulked joint. It is at once strong and reliable, and allows for considerable expansion without breaking the joint. Fig. 575 illustrates a joint of this kind, which is

made by inserting the beaded spigot end of one length into the socket of the other, a ring of gasket or lead tape being then pressed into the annular space to prevent the molten lead running through into the interior on being poured into the socket. Best pig lead should be used and well forced home with suitable caulking tools. In London this is the only kind of caulked joint allowed; hence the necessity of providing iron pipes of sufficient strength to enable the lead to be forced into the joint without bursting the socket. Ordinary rain-water pipes are useless for the purpose. To enable the joint to be properly caulked, the by-laws in London require the socket to be $2\frac{1}{2}$ in. in depth, and of sufficient width to give an annular space $\frac{1}{4}$ in. in width for $3\frac{1}{2}$- and 4-in. pipes, and $\frac{3}{8}$ in. in width for 5- and 6-in. pipes.

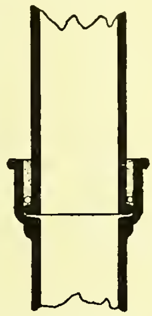


Fig. 575.—Caulked Joint

Mechanical joints are also used for connecting soil pipes. The usual description is the *flange joint,* where the lengths to be united are bolted together with a suitable insertion, such as rubber (either with or without a canvas lining) and asbestos. Gun-metal bolts and nuts should be used in preference to screws. Good work can be made with such joints, but their unsightliness is not a recommendation for adoption in exposed positions. Pipes with flange joints are much easier to repair—owing to the ease with which a single length can be removed—than those made with caulked joints.

Wrought-iron pipes with screwed joints have at times been used, but do not meet with much favour, partly owing to the difficulties of connection.

Joints to Closet Traps and Drains.—The joints between soil pipes and closet traps or drains are of many kinds. The by-laws of the London County Council have been adopted by a number of other authorities. Where the trap and the soil pipe or drain are formed of the same material, no difficulty is experienced. For instance, with a lead

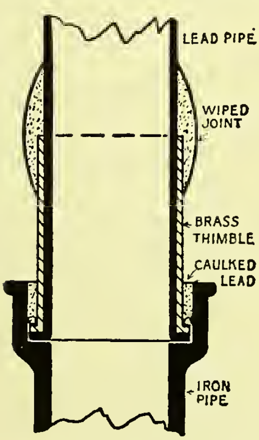


Fig. 576.—Joint from Lead to Iron Pipe, with Brass Thimble

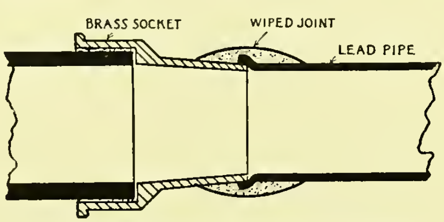


Fig. 577.—Joint from Iron to Lead Pipe, with Brass Socket

trap and soil pipe the joint can take the form of a wiped soldered joint; in the case of a stoneware trap and drain, the connection ought to be made with Portland cement; and an iron trap and pipe should be connected with molten lead properly caulked. For connecting lead to stoneware, or lead to iron, a thimble or socket, as the case may be, made of brass oı other suitable alloy, or copper, must be connected to the lead by means of a wiped or overcast metallic joint, and the joint made to the stoneware

with Portland cement, or to the iron with molten lead properly caulked, as shown in figs. 576 and 577.

The modes of joining different materials can perhaps be made clearer by the following table:—

Materials to be Connected.	Method of Jointing.
Lead to lead	Wiped or overcast metallic joint.
Iron to iron	Caulked with molten lead.
Stoneware to stoneware	Portland cement.
Lead to stoneware ...	Thimble or socket of brass or other alloy, or copper, wiped on to lead, and joint made with Portland cement.
Lead to iron	The thimble or socket as before, but joint made with molten lead properly caulked.
Iron to stoneware ...	Portland cement.

Patent Joints.—All these methods of jointing are eminently satisfactory, and are in accordance with the by-laws generally in force. As a rule, however, the by-laws allow, in a proviso, any other mode which is equally suitable and efficient. This opens the way to the introduction and use of other joints of approved pattern. Many patented joints are of doubtful value, but amongst those worthy of recognition may be mentioned the *metallo-keramic joint* and the *porcelain soldered joint*, both of which are indestructible joints for connecting stoneware to lead, the one with a strong copper-bit, and the other with a wiped plumbers' joint. (See also Vol. I, p. 81.)

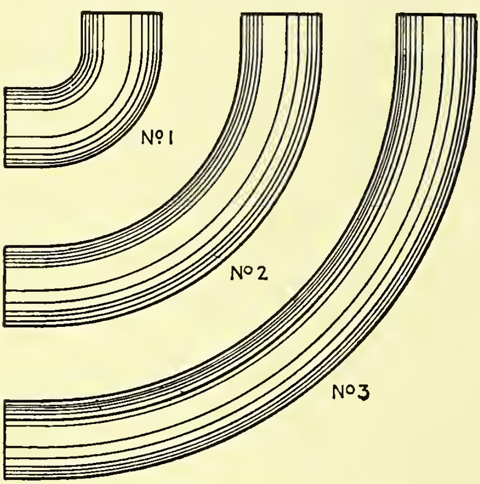


Fig. 578.—Bends in Soil Pipes

Shape of Pipes.—From time to time rectangular pipes have been used as soil pipes, but they are not suitable, as the angles permit of an accumulation of offensive matters. Circular pipes are now always insisted upon.

Bends.—Sharp angles—such as the old-fashioned elbow joint—should not be made in any soil pipe, and bends of any sort are to be avoided as much as possible. Where the latter are necessary, they should take the form known as "easy" bends. It is obvious that the "sharp" bend with a radius of one diameter, shown in No. 1, fig. 578, will check the flow much more than the easy bend with a radius of five diameters, illustrated in No. 3. As, however, a bend with the latter radius lacks neatness, the modification shown in No. 2, which has a radius of three diameters,

is generally preferred. Adequate fall should always be given to the branch pipe, and the junction of the branch and main soil pipes should never be at right angles.

Size of Soil Pipe.—There is no doubt that a pipe 3 in. in diameter is sufficiently large to take the waste matters from a number of water closets, and will be kept in a cleaner state by a smaller flush of water than a pipe of larger diameter. The drawback is the greater risk of siphonage.

The minimum size now recognized by many by-laws is a diameter of 3½ in., which is adequate, if ventilated properly, for one to six water closets in a building of ordinary height; but where a larger number discharge into the soil pipe, or if the building is of great height, the diameter should be increased to 4 in., which is sufficient for ten to twelve closets unless the conditions are of an exceptional character. The practice of using large soil pipes has been discountenanced by sanitarians for some years, as such pipes cannot be kept clean by the ordinary flushing apparatus.

Ventilation.—To secure proper ventilation, the practice now generally insisted upon is to carry the soil pipe upwards to a position where a safe outlet for foul air can be obtained. What constitutes a safe position is open to divergence of opinion, but it may be accepted that the outlet should never be below the eaves, nor less than 3 ft. above any window, ventilating flue or chimney (say) within 10 ft. Nearly all by-laws now in force require soil pipes to be continued upwards as ventilating shafts without diminution of the diameter. Upon the size of the ventilating pipe depends in no small degree the efficiency of the water-closet apparatus and the sufficiency of the soil pipe, for by increasing the size of the ventilating pipe the risk of siphonage is considerably lessened.

Anti-siphonage or trap-ventilating pipes are now officially recognized as essentials where more fittings than one are attached to a soil pipe. Where only one fitting is connected to a 3½-in. ventilated soil pipe there is very little risk of siphonage, unless the branch pipe is of considerable length, in which case a special ventilating pipe becomes necessary. The minimum size of 2 in. in diameter is stipulated in London. For buildings of medium height this will be found sufficient, but where the traps are attached to a soil pipe carried to a great height, or where there is a considerable distance between the uppermost branch and the top of the main ventilating pipe, the diameter of the trap-ventilating pipe should be correspondingly increased, so as to allow a quick rush of air downwards to take the place of the air displaced in the soil pipe by the falling discharge. Under some circumstances it is necessary to enlarge the pipe to 2½ in., 3 in., or even to the same size as the soil pipe to which it is connected.

To prevent siphonage, the pipe is best fixed as close to the trap as practicable, but experiments have shown that such pipes should not be connected to the crown or top of the trap, owing to the possibility of stoppage by solid matters being forced into the orifice. In London the position of the pipe is indicated as follows: "The ventilating pipe . . . shall be connected with the arm of the soil pipe or the trap at a point not less than 3 and not more than 12 in. from the highest part of the trap, and on that side of the waterseal which is nearest to the soil

pipe". It must also be connected in the direction of the flow. The position which is now generally accepted as being the correct one is shown in fig. 570. The trap-ventilating pipe should be connected to the soil pipe, or continued up to the same height as the main ventilating pipe, as indicated by figs. 570 and 571 respectively.

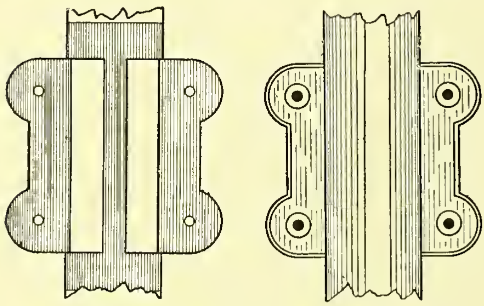


Fig. 579.—Tacks for Lead Soil Pipes, &c.

Trap-ventilating pipes are constructed like soil pipes. Iron pipes 2 in. in diameter are usually in 6-ft. and lead in 12-ft. lengths. In London the minimum weights are: for 2-in. lead pipe 45 lb. per 12-ft. length, and for 2-in. iron pipe 25 lb. per 6-ft. length, the thickness of the iron to be not less than $\frac{3}{16}$ in.

Methods of Fixing.—Lead soil and ventilating pipes are fixed by means of lead tacks, or by the use of metal brackets. The former consist of pieces of 7- to 10-lb. sheet lead, or specially cast plates varying from $\frac{1}{8}$ in. to $\frac{3}{8}$ in. in thickness. The method of attaching the tacks to the soil pipe is illustrated by the plan and back and front views shown in fig. 579. Cast tacks are much the stronger of the two, and are also more ornamental. Sheet-lead tacks require to be twice the width of cast tacks, as it is usual to fold the outer half over the nails or hooks (fig. 580). When fixed in a recess or chase, front wiped tacks (fig. 581) are sometimes employed, the nails or screws for fixing being passed through the solder. By this method the pipe can be strongly fixed, and the tacks take up less room. The appearance, however, is not quite so good. A better way of fixing in a chase is by means of lead collars wiped on in a similar manner to that indicated in the flange joint shown by fig. 573. Lead pipes should be strongly fixed; otherwise there is a tendency to "climb down" or drag from the wall. Three pairs of tacks per 10-ft. length are to be preferred, but if it is desired to use only four tacks, they should be fixed singly at equal distances but on alternate sides of the pipe, as in fig. 571.

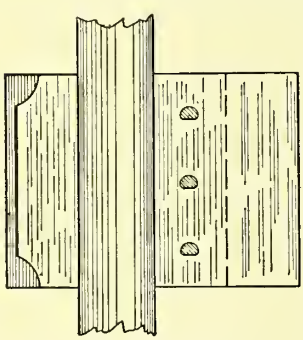


Fig. 580.—Folded Sheet-lead Tacks

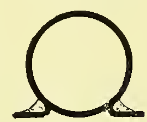


Fig. 581.—Front Wiped Tacks

It is preferred in some cases to fix the **soil pipes clear of the walls**, and this can be effected either by fixing wooden blocks, which project 1 to 2 in. from the face of the wall, and to which the lead tacks are attached, or by the provision of metal brackets built into or fastened on the face of the wall. The first method is somewhat unsightly, and has little to recommend it. The second is far better if gun-metal or galvanized cast-iron brackets

are used, as in fig. 582. These are fixed at the junction of the different lengths of pipe, which are connected by flange joints, an additional bracket being provided half-way between the joints, supporting a lead collar wiped on to the pipe. It is claimed for this method that the pipes are more strongly and equally supported than is the case with lead tacks; that greater freedom of movement is given to the pipe, and, as a consequence, it is less likely to fracture; and that the joints can be made without the brickwork being cut away as necessitated where the pipes are fixed to the wall direct. Lead pipes should never be fixed with metal clips or holderbats of the kind illustrated in fig. 583, as there is a risk of injury to the pipes.

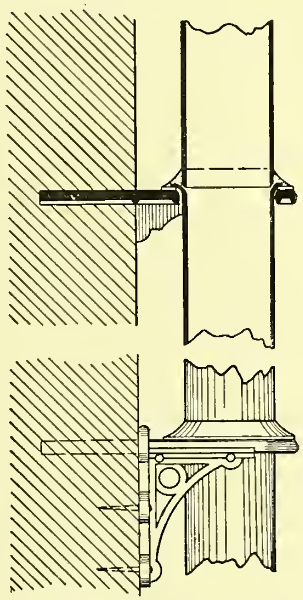


Fig. 582.—Brackets for Supporting Soil Pipes

Iron pipes are fixed by ears or lugs cast on the sockets, or by the use of metal clips, brackets, or holderbats, as in figs. 582 and 583. It is better to fix the pipes clear of the wall, so that they can be painted around and the joints easily caulked. Pipes provided with lugs can be fixed in this manner by inserting short pieces of barrel behind the lugs, through which the fixing nails are passed. The brackets and holderbats serve the same purpose.

The disconnection of the soil pipe from the drain by the provision of a trap at the foot, as shown in fig. 584, was much advocated at one time. Most codes of by-laws now, however, forbid the practice. In favour of disconnection, it was argued that, should the traps attached to the fittings inside the premises become affected in any way, the disconnecting trap afforded a safeguard against drain air entering the premises. Against the practice it can be argued that traps at the best are but necessary evils, and their multiplication, unless essential, is not to be advocated. Again, the provision of a trap in this position impedes the flow of the waste matters, frequently creates nuisance at the ground level, and makes it impossible to utilize the soil pipe for ventilating the

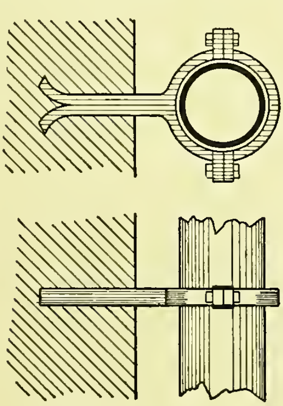


Fig. 583.—Clips or Holderbats

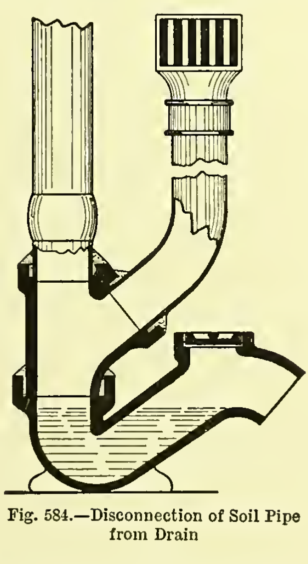


Fig. 584.—Disconnection of Soil Pipe from Drain

drain. In some cases the discharge of fæcal matter into a trap of this sort has resulted in such a nuisance that it has been found necessary to carry up a pipe, as shown, to act as a fresh-air inlet fixed at a sufficient height to prevent nuisance.

Soil Pipes as Drain-ventilators.—The provision of special pipes for ventilating the drains is not often insisted upon if there is a soil pipe in a position suitable for the purpose. In London a $3\frac{1}{2}$-in. soil pipe is considered sufficient for ventilating a 4-in. drain. Outside London a number of authorities permit the use of a soil pipe for this purpose, but require a minimum diameter of 4 in.

Drain-ventilating Pipes.—The rules governing soil pipes should apply with equal force to ventilating pipes, particularly in respect to position and construction. Up to recent years almost any material was accepted as being good enough for this purpose, but the by-laws in the metropolis now require these pipes to be constructed in the same manner as soil pipes. Unless fixed inside premises —in which case lead with wiped joints should be used—heavy iron pipe can be employed with advantage. Particular care should be given to the coating of pipes for ventilating purposes with a suitable solution, for, as pointed out previously, when their use is thus restricted the iron quickly corrodes, frequently resulting in a sufficient deposit of oxide of iron at the bottom to choke the pipe. To prevent these stoppages a "rust" pocket of iron or stoneware (fig. 585) is sometimes fixed, from which the rust can be removed through the sealed cover.

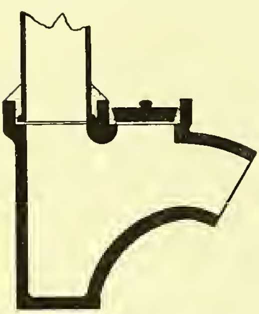


Fig. 585.—Rust Pocket for Iron Ventilating Pipe

Fresh-air inlets will be considered in Chapter X.

Cowls on the top of ventilating pipes are uncertain in action, and often absolutely prejudicial in the effects which they produce, particularly where the ventilating pipe is used as a soil pipe. In this case it should be remembered that not only must opportunity be afforded for the escape of foul air, but provision must be made for the rapid ingress of fresh air to prevent the siphonage of the attached traps. While under certain conditions cowls fixed in the position indicated accelerate the extraction of foul air, they more often impede the flow of fresh air into the pipe. It is worth noting, also, that the flow of air currents through tubes is so variable that a cowl which will perform what is expected of it under one state of the atmosphere is quite useless when other conditions are imposed.

Balloon Guards.—It is now generally admitted that an open, unobstructed orifice is to be preferred to a cowl which may develop into an impediment. With this in view the pipe is usually finished as shown in fig. 571, being simply provided with a wire dome or balloon of galvanized iron or copper wire—preferably the latter—to prevent extraneous matters from lodging in and stopping the pipe. The apertures or meshes of the guard must have a superficies not less than the sectional area of the pipe.

CHAPTER VIII

SLOP SINKS

In the minds of some persons there is a real distinction between **slop hoppers and slop sinks**, the former being understood simply as receptacles for slops, and the latter having, in addition to the means of disposal, a supply of hot and cold water for cleansing utensils. To avoid confusion, it is proposed to adhere to the term slop sink. As an accessory to the slop sink, a housemaid's sink, fitted with taps supplying hot and cold water, is extremely useful for washing-up purposes.

In an ordinary dwelling house of six to eight rooms a slop sink is unnecessary, as a suitable form of water closet will serve for the purpose. The needless multiplication of sanitary fittings is not desirable, as appliances not constantly in use are apt to be neglected. In large establishments, however, separate fittings to receive the slop water are essential, one or more being sometimes required on each floor.

The position chosen for slop sinks should be conveniently near the apartments over which control is to be maintained; and the general principles as to the situation of the sink apartment, and its lighting, ventilation, and construction are the same as those governing water-closet apartments.

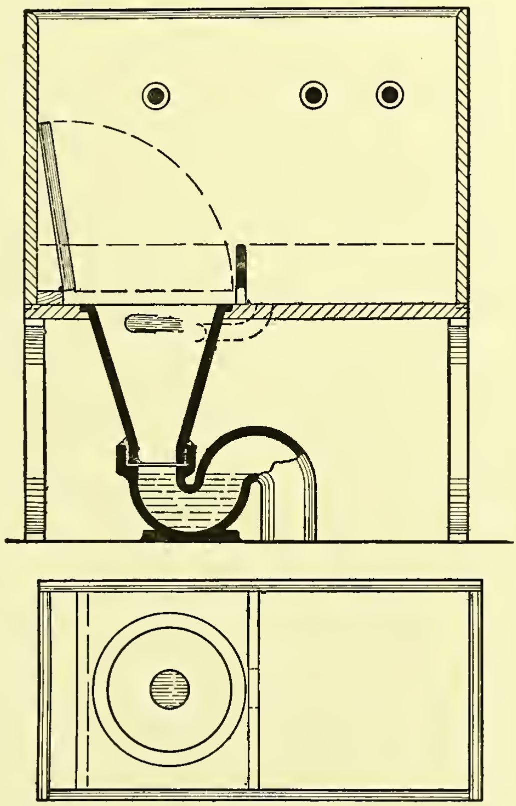


Fig. 586.—Combined Slop and Housemaid's Sink

The materials used in the manufacture of slop sinks are salt-glazed stoneware, porcelain-enamelled cast iron and fireclay, and vitro-porcelain. Occasionally slate or marble backs and sides are provided. The materials most suited for sinks are unquestionably porcelain-enamelled fireclay and vitro-porcelain, but enamelled iron is sometimes preferred on account of its greater strength.

The details of construction which are indispensable include the following: (*a*) A highly glazed surface, (*b*) no square angles, (*c*) a suitable flushing rim, and (*d*) an efficient flushing apparatus. The height of the front edge of a slop sink from the floor ought not to exceed 2 ft.

Combined Slop and Housemaid's Sink.—Fig. 586 illustrates a simple and

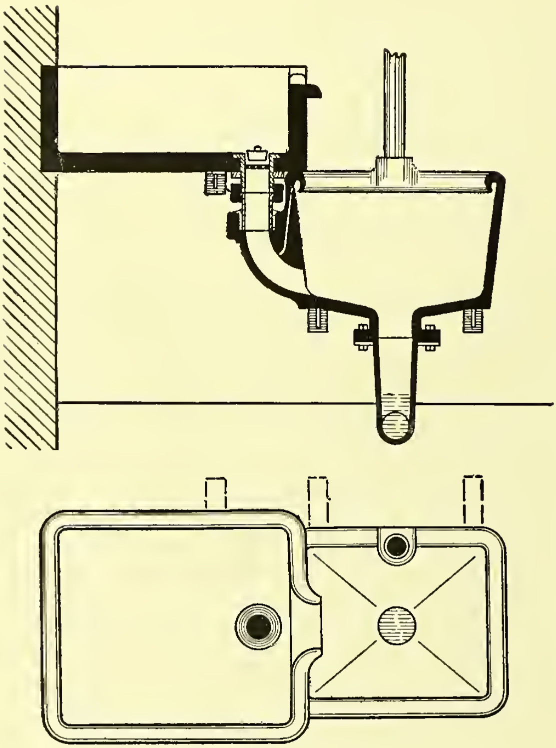


Fig. 587.—Improved Combined Slop and Housemaid's Sink

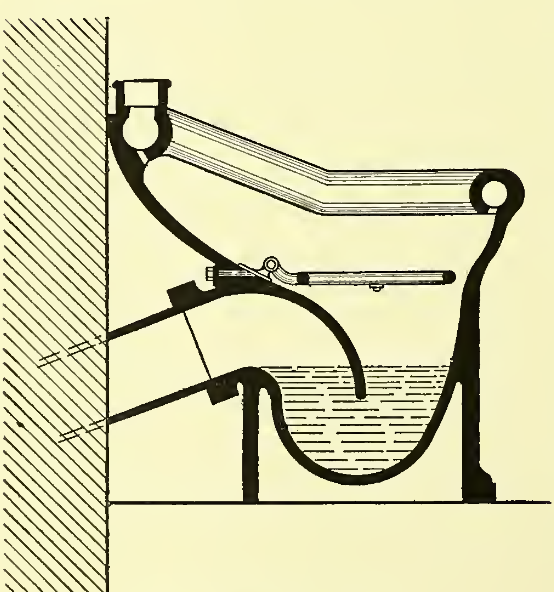


Fig. 588.—Slop Sink with Grid

cheap combination of a slop sink, having an earthenware pan and trap, with a slate rectangular housemaid's sink, provided with a high back to avoid splashing the wall, and arranged so that the waste water discharges directly into the pan. A side-inlet flushing arm is also provided, the pan being flushed from an ordinary water-waste preventer, or by a screw-down bib valve. The principal objections to be urged against this combination are the absence of a flushing rim to the slop sink, and the square angles present in the housemaid's sink. In another similar fitting the waste pipe discharges into the pan as shown by dotted lines, and the flushing tank is omitted. In some instances the pan and trap are fixed independently, and supplied with water by a valve and regulator, as in the case of certain water closets.

A much improved combination is illustrated in fig. 587, where both the sinks are of enamelled fireclay, and so arranged that the waste and overflow from the housemaid's sink discharge into the slop sink. Many varieties of these sinks can be had, some of which are fitted with either teak or stoneware drainers.

Separate Slop Sinks.—Where a housemaid's sink is not considered essential, a useful type of slop sink

is that shown in fig. 588, which consists of a whiteware pan and trap with flushing rim, and closely resembles a wash-down water closet with a raised back. A hinged gun-metal grid is attached to the pan to receive the pails and utensils during cleaning and filling. Such a grid is very useful. It should be hinged or made to lift out, and be fitted with rubber buffers. The sink is intended for use in conjunction with ¾-in. gun-metal draw-off valves for hot and cold water, and a 3-gal. flushing cistern worked by a hand pull.

The only objection to the provision of a slop sink with draw-off valves is the liability of these being put to a dual use, viz.: the cleansing of chamber utensils and the filling of water bottles. By keeping the valves away from the hopper, the risk of their becoming fouled by splashings of slops is to a great extent obviated. On the other hand, if supply valves are not provided, the chamber utensils will be taken to the housemaid's sink to be cleansed. With this in mind, the necessity for a separate housemaid's sink becomes more obvious.

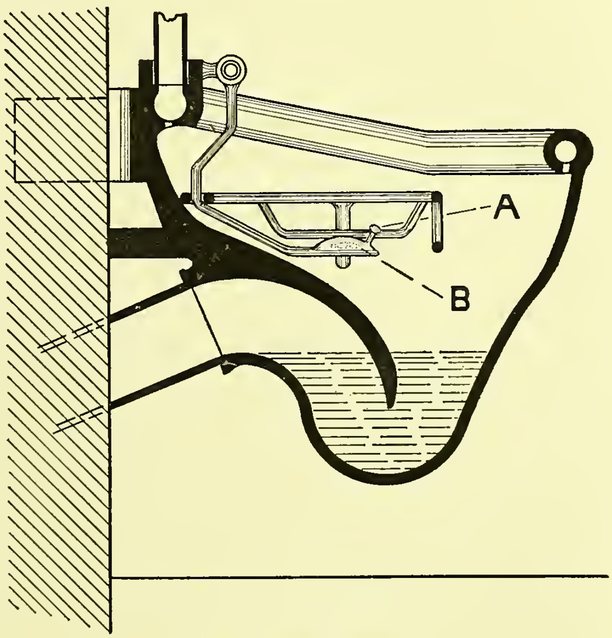


Fig. 589.—Hospital Slop Sink

In many dwelling houses it is a hard matter to find a suitable position for a slop sink, and resort must occasionally be had to an odd corner of the bathroom, water closet, or one of the staircase landings. To suit such positions, an angular combined slop and draw-off sink is found very useful, as the space occupied is small. The objection to fixing the sink in such a position is the necessity of a wooden casing.

Hospital slop sinks must be adapted for the cleansing of bed pans and urine bottles. Fig. 589 illustrates a sink designed to combine the cleansing of the bottles, pans, &c., with the discharge of the waste matters. The pan and trap are made in strong white-glazed ware, a jet and spray being provided at A and B respectively for the purpose of cleaning and scalding urine bottles and bed pans. The spray and jet are incorporated in the brass stand provided for pails, the stand being hinged, so that it can be turned up out of the way when slops are thrown into the fitting. The sink illustrated is of the corbel type, and embodies the best principles of a sanitary fitting designed for this particular work.

A glazed-ware drainer (fig. 590), on which to place the utensils when drying, can be attached to many forms of slop sink. The hardwood or composition inset rim on the front edge is useful in preventing damage to the fitting and to utensils.

Slop Sinks and Draw-off Sinks.—It is well to fix slop sinks that are used for bed pans, &c., independently of draw-off sinks. No risk is then entailed of the taps fixed over the latter being used for cleansing these utensils, in lieu of the spray and jet fitted to the former. A plentiful supply of hot as well as cold water to the spray and jet must be provided; otherwise the bed pans will be taken to the washing-up sink to be cleansed, and the special purpose of this type of slop sink will be frustrated.

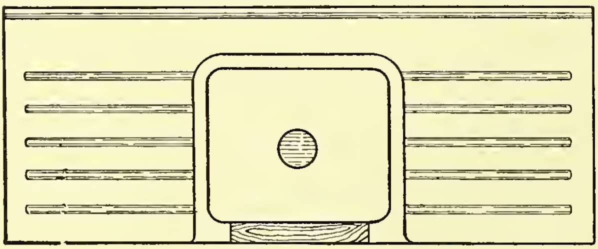


Fig. 590.—Glazed-ware Drainer

Enclosed Slop Sinks. — Complaint is sometimes made that offensive odours arise during the cleansing of the utensils, owing to the admixture of offensive particles with the vapour proceeding from the hot water. Many hospital authorities contend that hot water cannot be dispensed with in the cleansing of such utensils; so, to overcome the difficulty, a brass-bound glass cover with a rubber seating was introduced, and an attachment was made by which the flushing cistern was automatically discharged on the lifting of the cover, thereby ensuring the scouring of the sink each time it was used. The arrangement is an admirable one, but unfortunately it was found that under certain conditions the use of hot water in the sealed hopper created a partial vacuum, which made it difficult to open the lid after use.

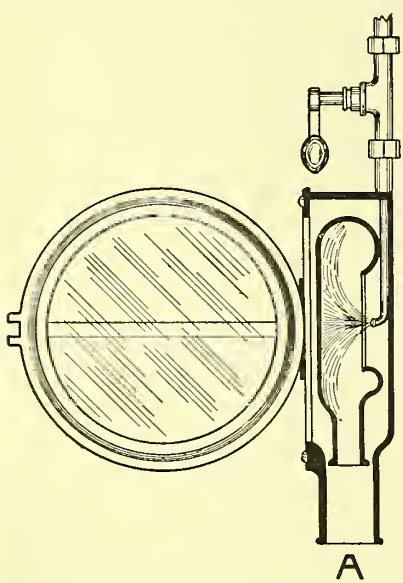


Fig. 591.—Bed-pan Flusher

Another special form of apparatus for cleansing bed pans is the patent **bed-pan flusher** (fig. 591), which consists of a porcelain-enamelled iron chamber, fitted with a plate-glass panelled water-tight door, and flushed by a valve or a flushing cistern through a jet as shown. An accessory to this flusher is a retaining valve, which can be fixed at A, enabling the flusher to be filled with water. A disinfecting agent can be placed in the chamber by hand, and the bed pan permitted to remain in the fluid for any period desired, or, instead of the disinfecting agent being

placed in the chamber by hand, a tank containing the disinfectant can be fixed overhead and connected to the flusher by a pipe governed by a valve. This flusher can be had separately or combined with a slop sink. In fixing, it is necessary to provide a separate trap to the waste pipe, but the latter can be connected to the waste pipe of the sink. The use of hot water is not recommended, for the reason given above.

Corbel Sinks.—Whether for private or hospital use, sinks that can be fixed independently of the floor (fig. 589) are to be preferred. They are supported in two ways: by a solid back, as shown, built into the wall, or by stoneware or metal brackets pinned into the wall. If metal brackets (other than gun metal) are employed, they should be enamelled, galvanized, or painted.

Enclosures.—Hoppers and sinks in houses should never be fitted with enclosures, but be freely exposed to the air. When cupboards are provided under the sinks, they occasionally become depositories for old house flannels, brushes, and dust.

The trapping of slop sinks is quite as necessary as the trapping of water closets. The by-laws in force in London specify an efficient siphon trap immediately beneath the sink, and the exclusion of bell, dip, and **D** traps.

Traps for pottery slop sinks are now usually made in one piece with the hopper, but the latter can also be obtained with lead or iron traps. If iron traps are chosen, they should be lined internally with white porcelain enamel. All traps should be enamelled white or very pale cream; in hospitals close attention has frequently to be paid to the waste matters deposited in them. Where lead traps are employed, a fireclay sleeve piece is often fixed inside, so as to present a white appearance on the inlet side. The traps attached to slop sinks are more likely to be subject to momentum than even water-closet traps, as a large body of water is often discharged quickly from a pail. For this reason, the depth of the trap seal should never be less than 2½ in.

Waste Pipes.—The by-laws in force in London require the waste pipes to be constructed in like manner to soil pipes, and of the same materials, *i.e.* lead or iron. The smallest diameter allowed is 3 in., and the weight of 3-in. lead pipe must be at the least 60 lb. per 10-ft. length, and of cast-iron pipe not less than 40 lb. per 6-ft. length.

It is alleged by some sanitary experts that the use of large quantities of hot water renders lead pipes unsuitable, owing to the alternate expansion and contraction. The expansion joint used for bath and lavatory wastes (fig. 513) fails to comply with the by-laws in force in London, which demand proper wiped plumbers' joints, such as are used for soil pipes. But where no such restrictions are in force, the adoption of expansion joints is suggested, in which case the lead should be equal in strength to 8- or 10-lb. sheet lead. Lead waste pipes with wiped joints must be regarded as unsatisfactory, although by adopting the method of fixing shown in fig. 582 freer movement may be given to the pipes. The effect of hot water upon lead also militates against the use of lead-lined iron pipes. The two metals expand and contract in a different ratio, and consequently separation is likely to take place between the lining and the outer casing.

Iron pipes are as a rule better than lead for the purpose of slop-sink wastes. Pipes with screwed, flanged, or caulked joints can be used, but they should be glass- or porcelain-enamelled inside and coated externally with a suitable solution. In fixing, clips or brackets which allow for movement of the pipes are better than ears or lugs which rigidly hold the pipes. In London the use of iron pipes entails fixing them outside, for (as previously mentioned in connection with soil pipes) lead must be used for internal positions.

Size.—Waste pipes of too large calibre are often used. For slop sinks fixed in dwelling houses, a pipe 2 or $2\frac{1}{2}$ in. in diameter is ample, if the fitting is subjected to fair usage and not converted into a dust bin. For hotels and hospitals, pipes of a greater diameter are necessary, as the sinks are less carefully treated, and are frequently made the depository of large substances which should rightly find some other resting place. For these premises, pipes 3 to 4 in. in diameter may be necessary.

Ventilation.—Waste pipes from slop sinks should be ventilated in the same manner as soil pipes, the waste pipe being continued upwards as a ventilating shaft, and proper trap - ventilating pipes being fixed as previously illustrated (figs. 570 and 571).

Foot Disconnection.—As the waste pipes are used as carriers for fæcal matter (especially in hospitals) to an extent at least equal to water closets, there is no need to depart from the principles enunciated when dealing with the foot disconnection of soil pipes. If an additional objection to the disconnection of a slop-sink waste is wanted, it is to be found in the use of large quantities of hot water, which, if discharging into a gully trap, would disperse at a low level in the external atmosphere in the form of vapour. The risk attaching to the diffusion of vapour from slop sinks in hospitals is evident, when it is considered that the discharges are often of an infectious nature.

Flushing Apparatus.—The apparatus for flushing the sink is generally entirely separate from that used for the bed pans and urine bottles. Flushing valves are employed in some instances, in which case the valve and service pipe should not be less than $1\frac{1}{4}$ in. in diameter. More often the apparatus takes the form of a flushing cistern worked by a hand pull, arm or elbow pressure, or treadle action. The size is usually limited to 2 gal., but 3 gal. should be obtained where possible, and the water should be discharged into the basin through a flushing rim, as in the case of a water closet. Cisterns for sinks are similar to those used for water closets, but a speciality is often introduced for hospital work in the shape of iron cisterns and flush pipes porcelain-enamelled outside. Brackets and cantilevers for supporting the flushing tank are also made of enamelled and galvanized iron or polished aluminium. The flush pipe from the cistern should under no circumstances have a diameter of less than $1\frac{1}{4}$ in.; $1\frac{1}{2}$-in. pipes are more often used.

Dual Valves.—The valves attached to the jets for cleansing bed pans and urine bottles can be arranged for either cold or hot water, or a dual valve supplying both hot and cold can be used. These valves are actuated in a variety of ways—by an ordinary lever, screw down, knee or treadle

action,—and are usually $\frac{1}{2}$ in. in diameter, and consequently the service pipe may be of the same size, but a fairly good head of water is requisite to obtain the necessary pressure for properly cleansing the utensils, and if this cannot be obtained, a pipe of larger diameter should be used.

CHAPTER IX

URINALS

No public places, such as schools, theatres, clubs, hotels, or the public thoroughfares, are deemed to be properly equipped without a sufficient number of urinals, and even in large private houses urinals, independent of the water closets, are now considered a necessity. The adoption of the pedestal form of water closet, and the slop or table top to valve closets, has rendered the provision of a special fitting unnecessary in ordinary houses, and as urinals in constant use can be kept in a better state than those used only occasionally, it is more advantageous to use a suitable water closet for the dual purpose than to provide a special fitting, which may be the subject of neglect, and eventually develop into a nuisance. Particular attention must be given to the construction of the apartments; the surfaces of all floors and walls should be formed with smooth and impervious materials, and all angles should be rounded.

Position and Plan.—The position in which a urinal is to be placed demands consideration as careful as that given to a water closet; indeed the urinal is the more common source of offence. For ranges of urinals, complete isolation from buildings, in which persons reside or are employed, should be aimed at. In factories and workshops, aërial disconnection between work rooms and the apartment in which the urinals are placed is now required. Where urinals are necessarily approached from buildings, an intervening ventilated lobby should be provided. If such a lobby is impossible, special mechanical appliances for ventilating the apartment are essential.

Public urinals are usually situated in positions away from buildings, and, owing to the ground available being restricted, it is becoming increasingly common to construct them below the level of the footway. From many points of view, and particularly that of decency, the change is commendable. In many districts there are glaring examples of badly situated and miserably planned urinals, which are attached in many cases to licensed premises, and are frequented by the public at large. Approached direct from the public footpath, of insufficient size, and unprovided with a door or screen, they often present a spectacle both indecent and offensive. In the London County Council (General Powers) Act, 1904, power was given to sanitary authorities in London to require that any sanitary convenience which is accessible from any street shall be so placed or constructed as not to be a nuisance, nor offensive to public decency.

A type of urinal still to be seen in the streets of our towns is notorious

for its objectionable characteristics. It is made of iron, which is often found to be corroded, is frequently unprovided with a water supply, and is of such a shape that it is difficult to use it without soiling one's clothes. An improved plan of urinals for four persons is shown in fig. 592. The combined width of the urinal and passage should not be less than 6 ft. Public urinals are now usually planned with the exit separate from the entrance.

Light and Ventilation.—Adequate means of lighting are required to all urinals, otherwise nuisance will occur. For above-ground urinals the natural movement of the air can be employed as the ventilating agent, if openings of sufficient size are provided in the walls; but with those situated underground it is often necessary to provide electric or water-driven fans.

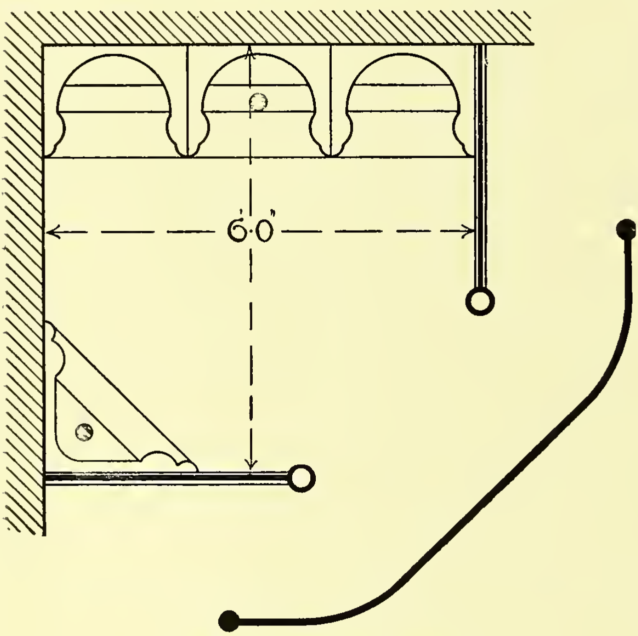


Fig. 592.—Range of Four Urinals

Number of Stalls.—There is not much definite information procurable as to the amount of urinal accommodation that can be insisted upon for different classes of public buildings. For elementary schools a length of 10 ft. per 100 boys is required by the Board of Education, and for factories and workshops "sufficient accommodation"[1] must be provided.

Bad Types.—One of the earliest kinds of urinal, of which examples can still be seen, consists of an apron formed by a York flagstone, or piece of slate, fixed parallel to the wall. Both sides of the apron, as well as the wall, become very foul, for even where a water supply is present, there is no possibility of the apron being flushed.

The most common form of urinal is made by covering a portion of brickwork with a coating of pitch or tar, or Portland cement, or by fixing a piece of sheet iron on a wooden partition to a height of 3 or 4 ft. from the floor, the urine being permitted to flow down the wall or metal into a gully or drain inlet. Sometimes a water supply is attached, usually in the form of a perforated or "sparge" pipe, supplied either through a stop cock or a flushing cistern. Portland cement is difficult to keep clean,

[1] The exact number of stalls is usually settled by the factory inspector, but a common allowance is 1 stall for every 40 employees.

as the urine salts destroy the surface, which then allows the absorption of filth and the deposit of fur. It is almost impracticable to maintain urinals of these kinds in a clean state, owing to the ease with which filth is absorbed and fur allowed to accumulate, the nature of the materials used, and the impossibility of adequately flushing the exposed fouling surfaces.

The materials employed in urinals should be smooth and impervious. Iron, painted or tarred, has been largely employed owing to its cheapness, but the paint is quickly dissolved by the urine, leaving the metal exposed to the ravages of corrosion. The surface of iron urinals is, more often than not, found in an exceedingly foul condition and smelling most offensively. Cement, York, and other stone, and unenamelled slate, are also unsuitable, being of too porous a nature. Salt-glazed stoneware, enamelled fireclay, and porcelain or whiteware are excellent materials for the purpose, and iron coated with vitreous or porcelain enamel may be included, although, on account of its liability to chipping, it is always subject to corrosion.

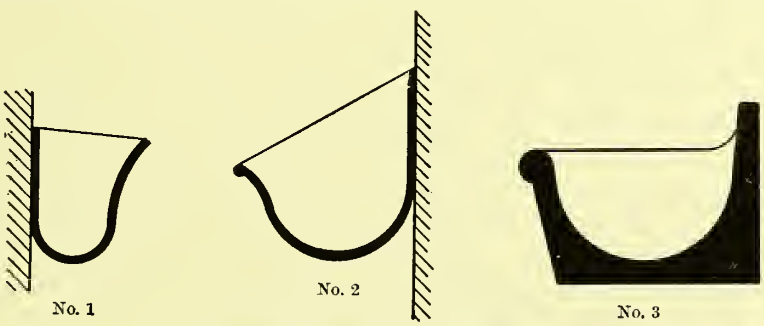


Fig. 593.— Drain-away Trough Urinals

Polished granite and marble are suitable for backs and partitions, but are slightly inferior to stoneware and fireclay. Slate should never be used in its natural state. It requires to be smoothed or rubbed, and either oiled or enamelled. Latterly, iron screens, glass- or porcelain-enamelled, have come into vogue, their qualifications being strength, lightness, and durability.

Shape.—The modern urinal is made in three distinct shapes: (1) The trough, (2) the basin, and (3) the stall.

Trough urinals were originally made in cement, slate, or stone, but are now made in plain or enamelled cast iron, salt-glazed stoneware, and enamelled fireclay. Iron troughs can be had in any length to order. Stoneware and fireclay troughs are usually made in lengths of 2 ft. 6 in., 3 ft., and 3 ft. 6 in., but a continuous trough, made up by a number of sections, can be obtained to suit any length or position. The backs are best if higher than the front; the front edge should not be too wide; and the front should be inclined towards the back to allow room for the user, and to prevent the splashings of urine from dropping direct on to the floor.

In fig. 593 are illustrated sections of plain drain-away troughs, Nos. 1 and 2 being of iron and No. 3 of strong stoneware.

The longitudinal section of the stoneware trough (fig. 594) shows that this has a weir at the lowest end, which retains a quantity of water for the purpose of receiving and diluting the urine. The water in the trough is changed at intervals by the discharge from a flushing cistern, worked automatically or by hand; or a service pipe is attached, and a constant stream of water is allowed to flow through the trough and pass over the weir into the drain. The dilution of the urine attained by the latter method is the best preventive of the deposit of fur.

In all trough urinals the walls should be constructed of slabs of vitrified

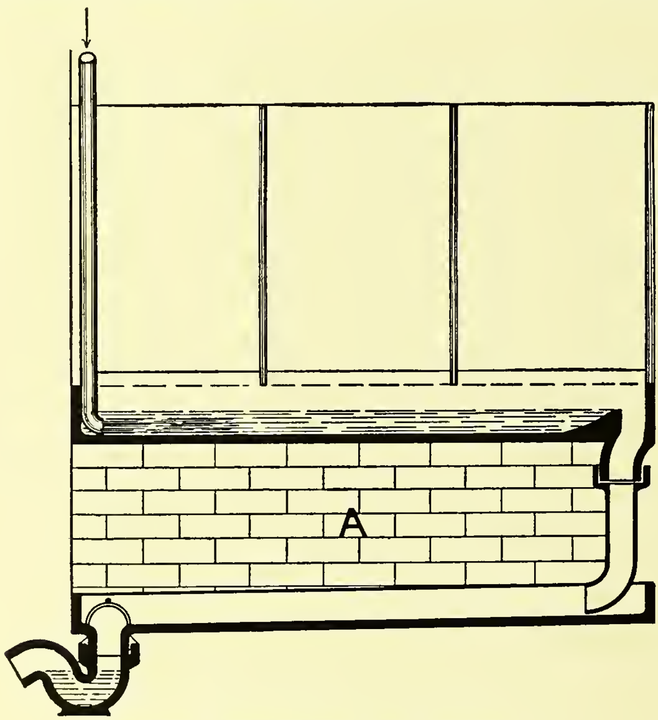


Fig. 594.—Stoneware Trough Urinal with Weir

stoneware, enamelled fireclay, or glazed bricks, or should be in cement trowelled to a smooth surface, or covered with tiles or other similar material. The front should be shaped as illustrated in fig. 595, to allow the user to stand well up to the trough. A channel below the level of the floor is required to receive the urine that is splashed over the front. The floor should be sloped to the channel or proper draining slabs fixed.

Trough urinals are fixed either with or without partitions (fig. 595).

When a cheap form of urinal is compulsory, the trough type, constructed properly, is preferable to the ordinary slate stall, but it is seldom used for good-class work, as it possesses large surfaces at the back and the under side of the front (the apron) unprovided with any means of flushing, which may therefore become very foul, particularly at A, fig. 594. In those flushed only at intervals, a large amount of encrustation also takes place.

Waste Pipe and Flushing.—There are two methods of treating the waste pipe to ensure the floor channel being cleansed. The first is to fix the trapped inlet to the drain at the end of the channel farthest from the trough waste, as shown in fig. 594. The objection to this is that the water used for flushing the channel is largely impregnated with urine, and there is also a possibility of the floor being flooded by the force of the discharge from the flushing tank. The better arrangement is that partly illustrated in section in fig. 595. The waste pipe from the trough discharges under the grating of the gully, which is fixed immediately below the outlet flow from the trough, and a special flush pipe is provided as shown, by which the troughs and channel are simultaneously flushed.

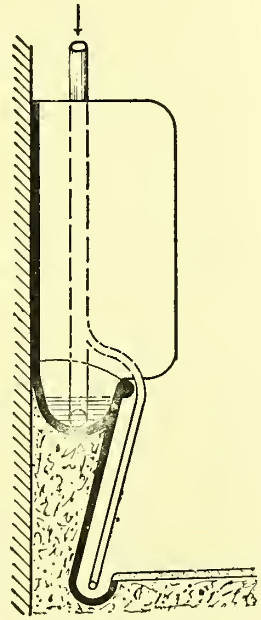


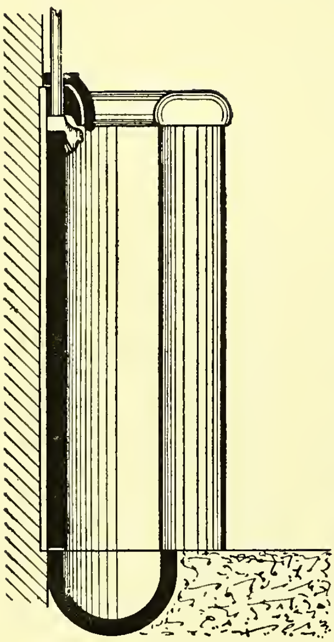
Fig. 595.—Vertical Section through Trough Urinal

Stall Urinals.—In the class of stall urinals are included both the worst and the best forms known to sanitarians.

The modern flat-back urinal—by which is meant a fitting with a straight back, either open or separated into a number of stalls by slab divisions—is an improvement upon the old cemented variety only in the materials employed. In principle they are bad, and, although by a careful selection of material and by excellence of workmanship their faults may be minimized, they are objectionable owing to the number of joints and the presence of angles which accumulate filth, a large fouling surface, the impossibility of adequately flushing the surfaces of the divisions, and the liability to splashing. Attention to the following details will, however, remove some at least of the objections. The partitions should be as small as possible compatibly with the maintenance of a suitable screen between the stalls, a rose or spreader should be used in preference to a sparge pipe, and a flushing tank of adequate capacity be provided. To avoid splashing it will be found advantageous to incline the back of the urinal, as in the circular type illustrated in fig. 597, rather than to fix it in a vertical position.

Divisions.—Slate backs and divisions are ordinarily used for these urinals, but the porosity of the slate should be remedied by oiling or by coating with metallic enamel. Vitreous- or porcelain-enamelled iron, polished marble and granite, are also used, but slabs of glazed stoneware or porcelain-enamelled fireclay are much to be preferred. Glazed stoneware divisions and backs are now made in one piece, the joints being arranged so that they come in the centre of the stall.

The usual thickness of the divisions separating the stalls is 1 in. to $1\frac{1}{2}$ in. In many instances they are 1 ft. 6 in. to 2 ft. in depth, and are carried down to the floor, varying in height from 3 ft. 6 in. to 5 ft. 6 in. As it is impossible to flush the divisions thoroughly, they should be reduced



as much as possible in area. Divisions 1 ft. to 1 ft. 6 in. project quite far enough for privacy. They should also be kept clear of the floor as shown in fig. 602, and the height restricted to 5 ft.

Slate, marble, or fireclay divisions can be fixed by building them into the wall or by attaching them to the back slab with metal angle pieces and screws, or nuts and bolts, in which case gun metal, brass, or copper should be used, as iron fastenings quickly corrode.

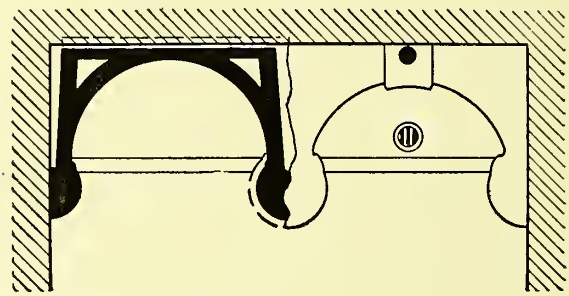
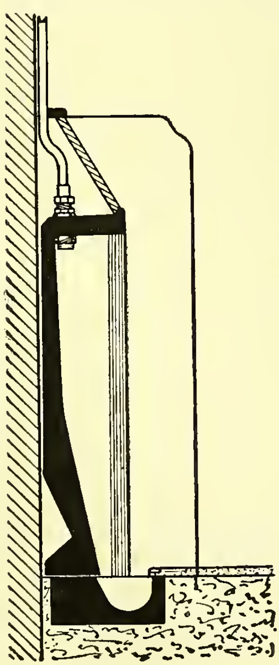


Fig. 596.—Circular-backed Urinal

Another way is to support the divisions on galvanized-iron standards, similar to that shown in fig. 602, 1 ft. to 1 ft. 6 in. in height, with holdfasts to keep the slabs in position. By this method they can be fixed clear of the back, thereby allowing the whole surface of the latter to be flushed. Occasionally cast-iron brackets are used for supporting the divisions, but as these accumulate dirt, and are subject to corrosion, they are somewhat unsatisfactory.



The divisions for adult use should never be less than 24 in. between the centres, but for children a width of 1 ft. 4 in. to 1 ft. 9 in. and a height of 3 ft. 6 in. are ample.

A glazed stoneware **floor channel**, with a slate

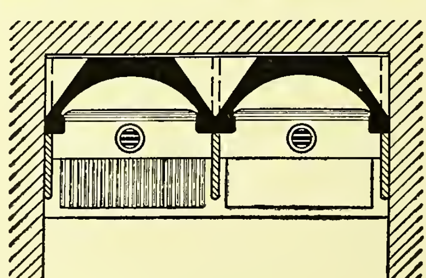
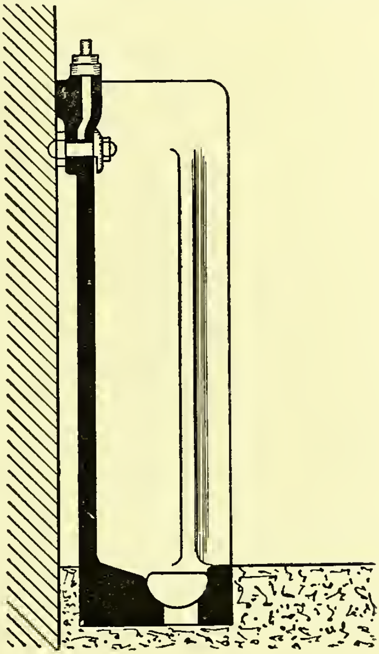


Fig. 597.—Stall Urinal with Circular Tapering Back

or fireclay tread, and a trapped drain inlet at the lower end, fitted with a galvanized-iron or brass hinged grating, should be provided.

Flushing.—A nozzle, rose, or spreader is preferable to a sparge pipe; but where the latter is used it should be of copper. Iron pipes soon rust, and the pinholes become choked.

Circular-backed Urinals.—A far better form is the circular-backed urinal illustrated in fig. 596. These are made in enamelled fireclay or salt-glazed stoneware, and in two shapes—semicircular and radial or oval,—varying from 3 ft. 6 in. to 5 ft. in height, and 1 ft. 9 in. to 2 ft. 3 in. in width. The variety shown is suitable for schools, and has a semicircular or cradle back and capping of brown or white-glazed fireclay, and a separate channel. It is flushed by a spreader, and the floor is sloped to the channel.



In fig. 597 is shown another urinal, nearly semicircular in plan, in one piece of white-glazed fireclay. It is provided with a taper back (the object of which is to deflect the urine and water into the channel without splashing). It is flushed by a patent spreader, and the base discharges into an open channel connected

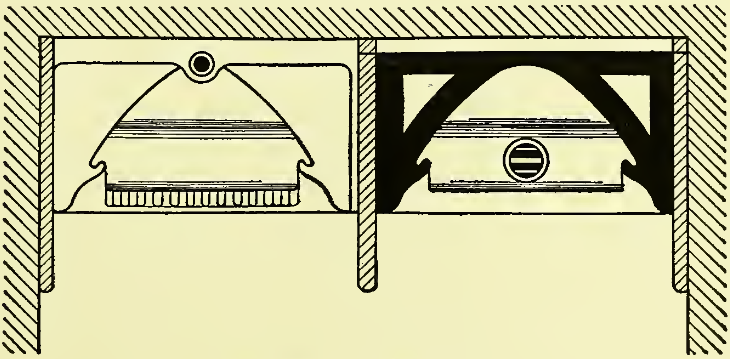


Fig. 598.—Radial-backed Urinal

to a trapped drain inlet. The stalls are separated by marble slab divisions, and marble tops and fireclay treads are provided. The whole of the circular back and the channel are flushed at each discharge of the cistern.

The latest improved type is the **radial or oval-shaped urinal** (fig. 598), in which the area of the back is decreased and the urine concentrated. The stall and channel are made in one piece of ware, and the stall is fitted with an anti-splash rim to retain the flush within. This fitting is

superior to the one previously described, as it has a less number of joints (the fitting being complete in itself), a better shaped back, an open continuous channel with easy access, and only one trap to the range of stalls.

All the foregoing are arranged for fixing on a straight wall. In fig. 592 is shown a somewhat similar urinal designed to fit in an angle.

Basin urinals possess certain advantages over troughs and stalls. The appliance itself is much smaller, the urine is concentrated, and the fouling surface reduced to a minimum. Where the appliance can be fixed independently of stalls, preference can be given to this type even over the circular-backed urinals. In the great majority of situations, however, it is compulsory to provide stalls with divisions to obtain the necessary privacy, and it is in this necessity for the provision of stalls and divisions that the objections to the basin urinal can be found. The misdirection of urine on the part of the user fouls the back and divisions, and unless regular attention is given to their cleansing by hand, they get into a worse state than the ordinary stall urinal.

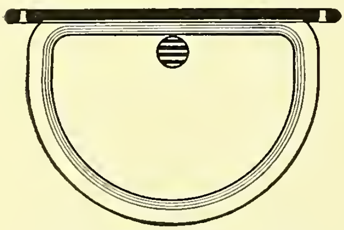


Fig. 599.—Wide-fronted Urinal Basin

Materials.—Basins are made in cast iron, either painted or enamelled, and in vitro-porcelain or whiteware, of which the latter is the most suitable. An objection to the use of porcelain or whiteware is its inability to withstand knocks or hard wear, and consequently in places, such as factories, where rough treatment is meted out to the fitting, it is frequently found necessary to adopt enamelled iron.

Shape.—Some engineers specify the wide-fronted basin (fig. 599), whilst others prefer the lipped basin (fig. 600). The wide-fronted shape probably catches a larger quantity of urine than the one with the narrow lip. The front rims of all basins should slope inwards, so that the droppings may trickle into the basin. To prevent the urine from running down the outside of the basin on to the wall, some basins are made with a projection (A, fig. 602), which causes the urine to fall direct on to the floor.

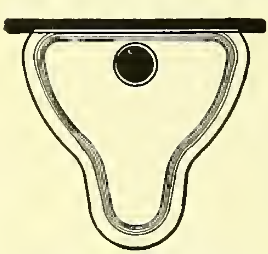


Fig. 600.—Lipped Urinal Basin

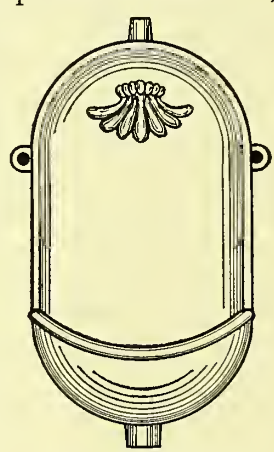


Fig. 601.—Flat-backed Iron Urinal Basin with Flusher

The ordinary enamelled-iron basin, if flushed at all, is usually fitted only with a draw-off tap discharging into it. An improvement on this is the flat-backed basin, also of enamelled iron, shown in fig. 601, where a shell is fitted to the back, to which a service pipe governed by a stop cock is often attached.

A flushing rim is quite as necessary to a urinal basin as it is to the pan

of a water closet or slop sink, and it is only by providing an efficient form of rim and an adequate water supply that the basin can be kept at all clean. Flushing rims, open or perforated, can now be obtained with iron as well as pottery basins. Fig. 602 shows an earthenware basin with a perforated flushing rim.

Trapped Basins.—Most basins are arranged so that the urine passes away at once through a grating in the bottom or back into the waste pipe. In fig. 602 is illustrated a form of basin which always retains a quantity of water. The objection to this fitting is that the outgo discharges at the back of the basin and is difficult of access, whilst the quantity of water retained is insufficient to effect any great dilution of the urine. In addition to the trapped outlet, a proper trap should be provided between the basin and the main waste pipe to which it may be connected.

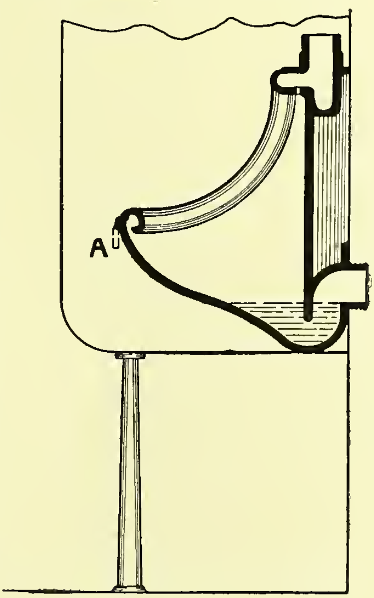


Fig. 602.—Trapped Basin retaining Water

Siphonic Urinals.—Some time ago a semicircular siphonic urinal for public use was designed, for three persons, a quantity of water being retained in a rather flat-lipped trough. The siphonic action was started by the increased head induced by the deposit of urine in the trough, the contents of the latter being siphoned out, and the flushing tank automatically and simultaneously discharged. The fitting, however, does not appear to have been adopted to any great extent, although the combined method of discharge and flushing lessens the quantity of water required.

To prevent the furring which takes place even on the best material, it is desirable to keep the surfaces always wet, and for this purpose to have a constant stream of water flowing through the fitting.

Cabinet Urinals.—Occasionally, for office use, a urinal is required in the form of a cabinet, which can be fixed in a room and yet be inconspicuous. The placing of urinals in rooms in which persons have to work is, however, open to serious objection. Cabinet urinals are now made of whiteware, with a flushing rim basin, trap, and waste pipe. They can be automatically flushed by an ingenious arrangement by which the flow of water is started on the lid being lifted up, and continues until the lid is closed. This method of flushing cleanses the basin and at the same time dilutes the urine, and thus prevents to a large degree the formation of fur. The wooden cabinet is a drawback to these fittings.

Supply and Waste Nozzles.—The inlet nozzle to the flushing rim and the discharging nozzle of the basin can both be vertical, or arranged in the slab back. In most basins the outgo nozzle is a part of the pottery, but basins are also made to receive a brass lining and union. Outlets should be

without any impediment in the form of the usual flat grating, the holes of which are easily stopped. A clear outgo is to be preferred, fitted with a domed grating of brass, galvanized or vitreous-enamelled iron, having straight bars. Basins with perforations in the pottery to form an outlet should be ignored.

Fixing.—Basins are usually fixed to the slab by bolts or screws passed through lugs which form part of the fitting; but care has to be exercised, as the lugs are easily broken. Where the inlet and outlet pass through the back slab, the basins are often fixed by the service and waste-pipe unions. A more satisfactory way is to have lugs attached to the back of the basin, which are passed through the back slab and secured in position by a metal pin or "paw" (fig. 603).

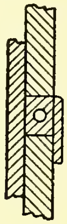


Fig. 603.—Basin Urinal Fixed with Lugs and Pins

Waste Pipes.—Urinals of the basin type are most frequently fitted with short waste pipes discharging into a channel in the floor, and specially made in enamelled iron, fireclay, and porcelain. As the internal surface soon becomes encrusted with fur, they should be fixed with lugs for screwing to the back, or attached by means of enamelled-metal clips, so as to be easily removed for cleansing. The outlet of the pipe should be bent in the direction of the flow along the channel. To avoid the accumulation of dirt behind the pipes, they are often made with flat ground backs, as in fig. 604.

A newer form of waste pipe or "conductor" is the vertical channel (fig. 605), which is made with curved rims to prevent the urine and water from being distributed over the floor. The basin and conductor are made in one piece, and the latter is entirely exposed and accessible for cleansing.

The waste pipes should discharge into a semicircular glazed-ware channel, and it is an advantage to sink a portion of the floor immediately under the basins, or to fix special hollow glazed treads, so that any droppings from the basin may fall into the sunk dish and drain away into the channel.

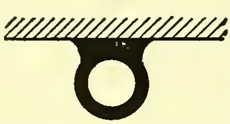


Fig. 604.—Flat-backed Waste Pipe

Fig. 605.—Vertical Channel Waste

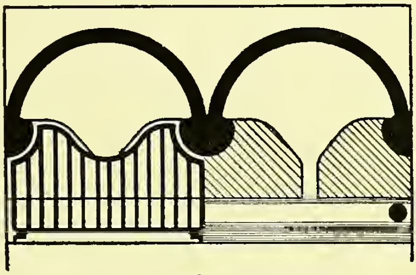
Size of Waste Pipes.—For a single basin or stall a waste pipe 1½ to 2½ in. in diameter would be sufficient to convey the waste matters to the drain; but for a range of urinals having six or more stalls a 3-in. waste pipe is required. In London the minimum size is stipulated as 3 in., and it must be constructed and ventilated in all respects as a soil pipe.

The arrangement of the waste pipes from a range of basins, where it is desired to trap each fitting separately, may be like that illustrated in the case of lavatories (No. 3, Plate XXXIII). More often, however, when fixed in ranges, short waste pipes discharging into an open channel, which in turn discharges into a trap attached to the main waste pipe, are provided, in which case only one trap is needed. In either case all inlets to the waste pipe must be trapped; and where more than one fitting is directly attached

to the waste pipe, suitable trap ventilation is requisite and, so far as London is concerned, must be provided.

To keep the waste pipes clear of the fittings, and to obviate the collection of filth which would accrue if the pipes were fixed on the face of the slabs, the waste pipes are on occasion carried through the wall at the back. This, however, is not always possible, and it consequently becomes necessary to fix them behind the slabs, which are kept sufficiently forward to allow the requisite space. This arrangement has obvious drawbacks.

Circular-backed stall urinals are provided with bottom outlets, either separately trapped or discharging into an open channel covered with a grating. Ranges of flat-backed stall urinals are usually provided with an open channel discharging over a trapped grating. For stall and basin urinals the open channel is to be preferred, as the number of traps is



No. 1

No. 2

Fig. 606.—Gratings for Urinal Channels

reduced, the risk of stoppage is lessened, and the waste pipes can be arranged so as to facilitate access in case of accidents.

The **gratings** for the channels and drain or waste pipe inlets should be of gun metal, brass, or galvanized iron, and either hinged or arranged so as to be lifted out. For channels, wide gratings having narrow divisions, as shown in No. 1, fig. 606, should be preferred to the kind illustrated in No. 2, as the former expose a smaller surface to the droppings and allow for better drainage. For the inlets, cobweb or domed gratings with straight bars should be used.

Lead, iron, brass, and copper are used for **sparge pipes**; but, as iron is rapidly corroded, brass and copper are preferable. In size, sparge pipes vary from ½ to 1½ in. in diameter, according to the area of the surface to be flushed. They are often supplied with water by means of a screw-down stop cock; but sometimes a flushing tank is attached, either automatic or worked by hand. Perforated pipes have little to recommend them, as the holes frequently become choked, the water is unevenly distributed over the fouling surface, and frequently it falls directly into the channel, especially when the flush is nearly exhausted, splashing the floor and also the boots of the person using the convenience. To prevent the splashing, and to direct the water on to the surface to be flushed, a shield is sometimes attached to the pipe, or fixed so as to cover the pipes, but in use it is only a partial success.

The practice of fixing sparge pipes is not confined to the slab type of

urinal, for copper sparge pipes fitted with shields are fixed to circular-backed urinals, and they are also employed in some cases—lead pipes being occasionally used—for flushing the floor channels, as shown in fig. 607.

A great improvement upon the sparge pipe is **the spreader**, shown in figs. 596 and 598, which consists of a metal dome with a slit cut in such a manner as to distribute the water over the surface of the stall.

Urinal basins are frequently flushed by a **screw-down stop cock** or **self-closing push valve**, $\frac{1}{2}$ to $\frac{3}{4}$ in. in diameter. This mode of supply is inefficient, as very few persons who use the convenience take the trouble to flush it.

With the exception of independent urinals of the office type, **flushing tanks** should be provided in connection with all urinals. As a rule, those that are automatic in action should be selected, if no objection is made by the local water company. There should be no connection between any water main or cistern, used for storing potable water, and a urinal, either by means of a direct service pipe or a lift-up or spindle valve.

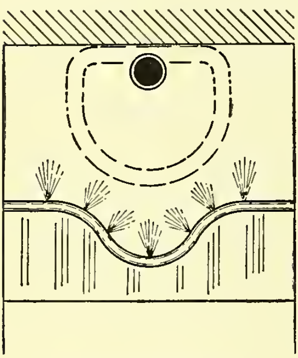


Fig. 607.—Sparge Pipe for Floor Channel

Many water companies object to automatic tanks, and some even insist upon a double-valve waste-preventer, which necessitates the handle being held the whole time the cistern is discharging. Likewise, screw-down or similar valves are not allowed unless the water is supplied by meter. The size of the flushing cistern for private urinals is limited by some regulations so that not more than 1 gal. of water is discharged at each flush. Even where automatic cisterns are permitted, the use of a stop cock for supplying the cisterns is frequently prohibited, a requirement being made that a small disc shall be inserted in the union of the service pipe for the purpose of permanently regulating the supply of water to the tank. The allowance of water generally considered requisite is 1 gal. per stall or basin, and the frequency of the discharge depends upon the extent to which the convenience is used, and varies from a few minutes to several hours.

Flushing cisterns for urinals, in addition to being made of cast iron (painted, galvanized, or enamelled) and wood with lead or copper linings, are often made of glazed fireclay, slate, and marble, as well as of polished wood, copper, brass, or marble with glass panels. If iron cisterns are used, they should be vitreous- or porcelain-enamelled. Some cisterns are fixed on brackets built in or screwed to the walls. Others are provided with lugs for screwing to the wall. With independent urinals a central fireclay pillar is often provided to support the cistern.

Non-automatic cisterns for urinals are actuated either by an ordinary pull or by door action. For the latter a siphon cistern must be used. For private dwelling houses, or places where the urinal is not in constant use, the best method of working the tank is by a hand pull, in which case the siphon tank illustrated in figs. 554 and 559, or any similar cistern, can

be used. Door-action cisterns are apt to get out of order, and are somewhat wasteful, the urinal frequently being flushed when not required.

Automatic Tanks.—In public or semi-public places the proper method of flushing is by means of an automatic tank with a drop-by-drop or other regulated supply. These are mostly provided with an annular siphon, as in fig. 568 (with or without the patent arrangements referred to), the action of which is started by the sudden increase of the head of water contained in the tank, due to the operation of a reversed-action ball valve. Water is generally supplied through a small pet cock, as well as the ball valve, the former being regulated to fill the cistern to the level of the siphon pipe at any speed desired. As the cistern fills, the ball valve is brought into action, quickly raising the level of the water in the tank and accumulating sufficient head to overflow into the siphon pipe, driving the air before it, and thereby starting the siphonic discharge. When the water is lowered to the bottom of the dome, air enters the tube, and the siphonic action is at once broken. In this type of cistern a reversed-action ball valve is indispensable, for otherwise the small incoming quantity of water from the pet cock would dribble away down the siphon pipe without starting the siphonic action.

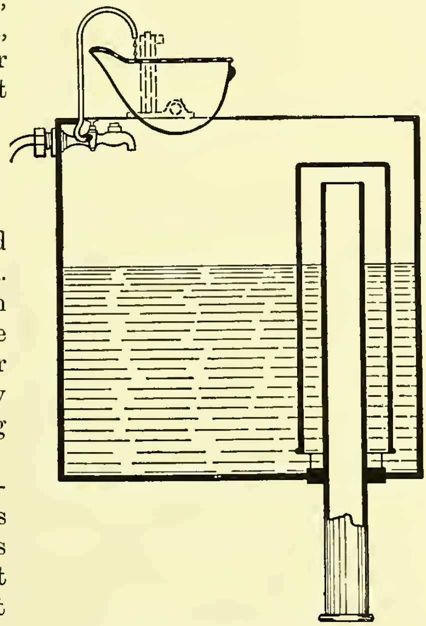


Fig. 608.—Automatic Flush Tank

In fig. 608 an annular siphon is provided, and a "tipper" is balanced as shown, into which a supply of water is sent by a small jet regulated by a pet cock. The tipper is hung slightly out of centre, and when it is full it turns over, discharging the contents into the tank. The back being weighted, it then reverts to its upright position, and the process is repeated until the annular space is full up to the level of the siphon pipe. The next discharge of the tipper forces water into the pipe and starts the siphon. India-rubber buffers should be fixed for the tipper to impinge against; otherwise it will be noisy in action. A drawback to some examples of this type is the splashing that occurs.

Size of Flush Pipes.—The flush pipe for trough urinals should never be less than $1\frac{1}{4}$ in. in diameter, and for a range of stalls exceeding three in number a pipe of larger diameter is better. Where a $\frac{1}{2}$-in. pipe is connected to the main flush pipe for cleansing the channel, as shown in fig. 595, the larger pipe should be at least $1\frac{1}{2}$ in. in diameter.

It is not usual to flush more than six stalls from one flushing cistern, owing to the difficulty experienced in distributing the water equally. The general practice is to arrange the flush pipe in the manner indicated in fig. 609, which illustrates an arrangement suitable either for sparge pipes,

the flushing rims of basins, or patent spreaders. Assuming that the six branch pipes marked C have an internal diameter of $\frac{1}{2}$ in.,—on the basis that the discharging capacities of pipes are to each other as the square root of the fifth power of the pipe diameters,—those marked B must be $\frac{3}{4}$ in., and A 1 in. in diameter.

For ladies' use in public conveniences, **urinettes** are occasionally provided. The appliance takes the form of an elongated ware basin fitted with a flushing rim. They possess a rather large fouling surface, and the area

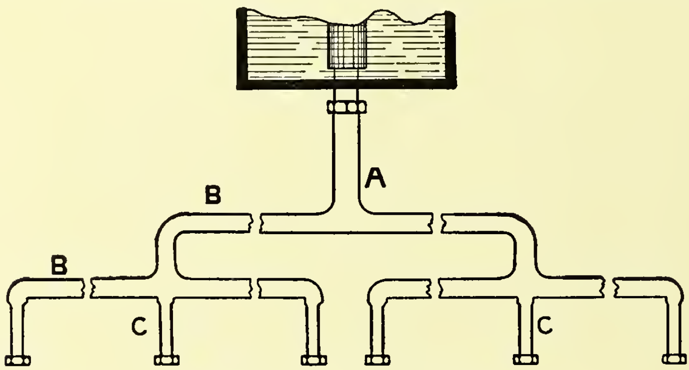


Fig. 609.—Arrangement of Flush Pipes

of the water in the trap is small. They can be flushed by separate cisterns worked either by seat action or by a hand pull, or a range can be automatically flushed from a single cistern. The urinette occupies less space than an ordinary water closet, but under ordinary conditions a wash-down closet is to be preferred.

The best method of **preventing encrustation** is a plentiful supply of clean water frequently applied to the surfaces of the fitting. If a piece of common washing soda is placed in the basin or trough, it will assist in keeping the fitting and waste pipe free from deposit. To remove "fur", muriatic acid (spirit of salts) is the most effective agent.

CHAPTER X

DRAINAGE

Combined or Separate System.—In the planning of drainage systems information is necessary, in the first place, as to the means at hand for the disposal of the sewage—whether into a cesspool, by a small system of purification, or into a public sewer, and, if the last, whether a combined or separate system is in operation. With respect to disposal by means of a cesspool, private purification works, or a separate system of public sewerage, the one principle underlying all is to separate the surface water from the sewage; the object of the separation being to lessen the quantity of liquid

to be dealt with, either in the cesspool or at the private or public sewage-disposal works. The exclusion of surface water from the sewage drains is in some instances a serious factor, as it eliminates a large quantity of water that is exceedingly useful in keeping the drains clean and well flushed.

Whether a combined or separate system is adopted, the general principles underlying the construction of the drains remain the same.

Qualifications of a Good Drain.—The following qualifications must be considered as indispensable in a good drain:—

(1) It should be of sufficient size and of suitable materials, and be both air-tight and water-tight, and constructed so as to withstand a greater pressure than it would be subjected to during use.

(2) It should be laid in straight lines from point to point, with a sufficient and equable fall, so as to be self-cleansing, and all turns or bends and all important junctions should be made, wherever practicable, in inspection chambers.

(3) It should be aërially disconnected from the sewer or cesspool, and provided with adequate and suitable means of ventilation in the way of inlets and outlets, so placed as to secure a constant current of fresh air through the drains without the possibility of nuisance.

(4) Wherever practicable, it should be situated outside the premises, and a separate drain be provided to each house or particular set of premises.

(5) All drain inlets, other than those from water closets, slop sinks, and urinals, should be outside the buildings, and all waste pipes should be disconnected and made to discharge into suitable trapped gullies.

(6) All inlets, other than those provided for ventilation, should be properly trapped.

Traps.—Reference has been made in Chapter II to suitable traps for various positions and uses, and to the necessity of efficiently disconnecting the various waste pipes, and aërially separating the drainage from the sewerage system.

Drains outside Buildings.—In London a drain must not pass under a building unless any other mode of construction is impracticable. For terrace houses without a secondary means of access, the drain must necessarily be laid under the house to its connection with the sewer in the public road, but in detached and semi-detached houses the drain can and should be kept entirely outside the building. In this way the opportunity for the dissemination of offensive gases inside the premises will be reduced to a minimum. The qualifications numbered 5 and 6 above are also obligatory in London, but in certain urban and rural districts, where the by-laws are framed upon the model issued by the Local Government Board, every waste pipe must discharge into the open air 18 in. distant from the trapped drain inlet. In London the waste pipe may discharge over or into the gully above the level of the water in the trap. For reasons indicated elsewhere, the latter arrangement is to be preferred.

Size of Drain.—To ascertain the size of the drain required for a particular set of premises, regard must be had to the number of water closets,

baths, sinks, lavatories, &c., and—if the storm water is also to be conveyed —the superficial area of the collecting surfaces, *i.e.* the roofs and paved surfaces. At one time single houses were frequently drained by 9-in. pipes, a size far in excess of that required, and also much too large to permit of the drain being scoured by an ordinary discharge from a sanitary fitting. As a result, the pipes rapidly silted up in many instances. 6-in. pipes are now more commonly used, and are sufficient for mansions and other large buildings, but houses of moderate size can be adequately drained by 4-in. pipes. The by-laws in London stipulate the latter size as the minimum. By the use of as small a drain as is compatible with the work to be performed, the drain will be more self-cleansing, and there will be less likelihood of the generation of offensive gases in its interior.

Fall for Drain.—Most by-laws now prescribe that the drain shall be laid with a suitable fall, by which is meant such a fall as will create sufficient velocity to convey the solid matters away with the liquids to their destination. For circular *sewers*, where the flow is constant, a velocity of $2\frac{1}{2}$ to $3\frac{1}{2}$ ft. per second, according to the size of the pipe, is sufficient to provide the necessary scouring force to maintain the channel in a clean state, and for *drains*, where the flow is intermittent, a velocity of 4 ft. per second is now usually regarded as satisfactory, unless the amount of sand and other heavy detritus is exceptional, in which case a greater velocity should be obtained.

It is often said that a velocity of 4 to $4\frac{1}{2}$ ft. per second will be ensured if the drains are laid to the following gradients:—1 in 30 for a 3-in. drain; 1 in 40 for a 4-in.: 1 in 50 for a 5-in.; 1 in 60 for a 6-in.; and 1 in 90 for a 9-in. But this empirical value is seriously misleading, and many drains which have been laid in accordance with it have had to be taken up, or a special flushing tank has had to be provided to keep them free from deposits. If there is in any particular case a daily flow of sewage not more than sufficient to keep a 4-in. drain, laid to a gradient of 1 in 40, free from deposits, no advantage would be gained by using a larger pipe, even if it were laid to the same gradient, and if the larger pipe were laid to a lower gradient, in accordance with the rule, deposits would certainly occur.

Materials.—The materials of which drain pipes are now made are, for all practical purposes, limited to iron and stoneware, the relative qualifications of which have been discussed in Chapter II. For drains passing under or through buildings, or near the surface of roadways, and for positions generally where a drain is required that is not only gas- and water-tight when laid but will permanently remain in the same condition, greater reliance can be placed upon iron.

Length.—Iron pipes cast vertically have a more even thickness and should be selected. The usual length is 9 ft., but 6-ft. lengths are also made as well as short pieces. Cast-iron drain pipes are of a much heavier type than soil pipes, and are not provided with lugs. The thickness of the metal and weight of the pipe should not be less than those required by the by-laws in operation in London, which will allow for the pipes being properly caulked with metallic lead.

Thickness and Weight of Cast-iron Drain Pipes in London.		
Internal Diameter in Inches.	Thickness of Metal not less than—	Weight per 9-ft. Length (including Socket and Beaded Spigot or Flanges—the Socket not to be less than $\frac{3}{8}$ in. thick) not less than—
3	$\frac{5}{16}$ in.	110 lb.
4	$\frac{3}{8}$ „	160 „
5	$\frac{3}{8}$ „	190 „
6	$\frac{3}{8}$ „	230 „

The minimum depth of the socket should be $2\frac{1}{2}$ in. with a $\frac{1}{4}$-in. annular space between it and the spigot end, which it has to receive.

In the following table are given varying weights and thicknesses of iron pipes in 6-ft. and 9-ft. lengths, including the sockets and spigots:—

Thickness and Weight of Iron Drain Pipes (W. Macfarlane & Co.).			
Internal Diameter in Inches.	Thickness of Metal.	Weight per 6-ft. Length.	Weight per 9-ft. Length.
3	$\frac{5}{16}$ in.		110 lb.
3	$\frac{3}{8}$ „	70 lb.	
$3\frac{1}{2}$	$\frac{3}{8}$ „	80 „	
4	$\frac{3}{8}$ „		148 and 160 lb.
$4\frac{1}{2}$	$\frac{3}{8}$ „		160 lb.
5	$\frac{3}{8}$ „		190 and 194 lb.
6	$\frac{3}{8}$ „		230 lb.
6	$\frac{1}{2}$ „		292 „
7	$\frac{1}{2}$ „		353 „
8	$\frac{1}{2}$ „		402 „
9	$\frac{1}{2}$ „		452 „

Iron drain pipes are not made to withstand any certain bursting strain, but as they are cast of heavier metal than the standard soil pipes referred to on p. 231, which can be proved to stand a head of 200 ft. of water, equal to an internal pressure of 86 lb. per square inch, it can be safely assumed that the drain pipes will be equal to any bursting strain to which they may be subjected. Roughly, they can resist a bursting pressure of between 300 and 600 lb. per square inch.

The numerous advantages of iron pipes over stoneware include greater resistance to pressure (either crushing or bursting), fewer and stronger joints, and more permanent soundness. Against these qualifications must be placed the rougher internal condition when compared with vitrified stoneware, greater liability to corrosion, and increased cost. Two of these

objections can, however, be successfully removed by coating the internal surface with glass enamel, and if this is done the third can be ignored, if respect is paid to the more lasting character of the work.

The internal surface of iron pipes should be free from projections; the pipes should ring true and be perfectly straight. Unless glass-enamelled, they require coating with Dr. Angus Smith's solution.

Joints of Iron Pipes.—The joint mostly used in connection with iron pipes is the caulked joint made with molten metallic lead, which is both easily made and reliable. Iron pipes can be successfully jointed with Portland cement, and such joints will resist a fair pressure. In London the use of metallic lead is compulsory. Occasionally for drains laid in water-logged districts some type of flange joint is necessary, owing to the difficulty of making caulked joints. The pipes can be bolted together in the usual manner with some suitable insertion.

Stoneware Pipes.[1]—By the by-laws in force in London, stoneware pipes are required to conform to the following specification:—

Internal Diameter in Inches.	Thickness of Pipe, not less than—	Depth of Socket, not less than—	Annular Space for the Cement, not less than—
3	$\frac{1}{2}$ in.	$1\frac{1}{2}$ in.	$\frac{5}{16}$ in.
4	$\frac{5}{8}$,,	$1\frac{3}{4}$,,	$\frac{5}{16}$,,
5	$\frac{5}{8}$,,	2 ,,	$\frac{5}{16}$,,
6	$\frac{5}{8}$,,	2 ,,	$\frac{5}{16}$,,
9	$\frac{3}{4}$,,	2 ,,	$\frac{7}{16}$,,

Stoneware pipes (both the barrel and the socket) ought to be true in section and alignment, hard-burnt (showing when broken a black or nearly black centre), non-porous, and well glazed, and ought to emit a good ring when struck.

Reliable information as to the bursting and crushing strengths of stoneware pipes is not readily obtainable (the breakdown tests vary even among pipes of the same manufacture), but actual tests applied to 6-in. stoneware pipes gave the following results:—*Beam Test,* three pipes broke under loads of 1·66, 1·70, and 1·90 tons respectively; *Bursting Test,* three pipes burst under pressures of 250, 250, and 625 lb. per square inch respectively. When a crushing test is applied to stoneware pipes it is usually specified to be 1 ton distributed over the length of the pipe, which is placed between a cradle and saddle with an interposed layer of felt.

Messrs. Doulton & Co.'s "tested" London stoneware pipes are each subjected to an internal hydraulic pressure of 30 ft. head of water, which represents about 13 lb. to the square inch. This pressure does not, of course, represent the maximum test which can be applied, but is regarded as sufficient to ensure that the pipes are of a high quality. Messrs. John Knowles & Co. are prepared to supply pipes tested to 30 lb. per square inch, a pressure equal to 70 ft. head of water.

[1] For different kinds of joints in stoneware pipes, see pp. 214–219, Vol. I.

Base for Drain Pipes.—In laying a drain it is most important that the pipes should be properly and evenly supported on a solid base or bed. The usual method is to provide a bed of cement concrete about 6 in. in thickness, and projecting on each side of the drain to an extent at least equal to the external diameter of the pipes used. This method is essential for stoneware drains which require an even and close support throughout the entire length, but iron pipes, if situated above the ground, can be satisfactorily supported on piers (at least one support being provided for each length of pipe) or carried on brackets.

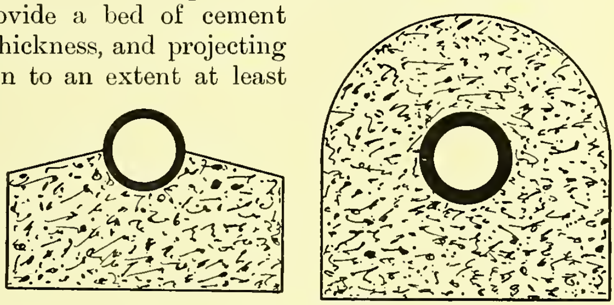


Fig. 610.—Stoneware Drains
No. 1, Outside a building; No. 2, Under a building.

The by-laws in London, in addition to requiring suitable supports for iron pipes and a bed of concrete for stoneware pipes, insist upon the latter being embedded to the extent of half the diameter, if situated outside the premises, and completely embedded in concrete at least 6 in. all round if the drain passes under a building. Iron pipes below the ground must be laid upon a bed of concrete and partly embedded. Fig. 610 shows in section stoneware drains for external and internal positions, and fig. 611 iron drains carried by means of piers and brackets.

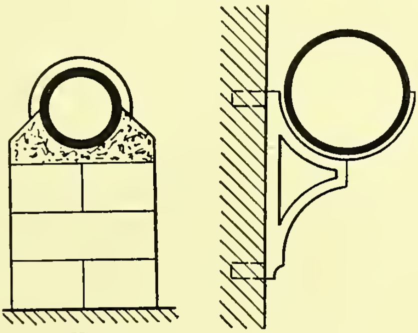


Fig. 611.—Iron Drains
No. 1, On piers; No. 2, On brackets.

Lime concrete is not, as a rule, allowed. Good cement concrete is generally stipulated, composed of clean gravel, hard brick broken small, or other suitable ballast, well mixed with clean sand and good Portland cement in the proportion of two parts of sand, one part of cement, and six parts of other material.

Protection for Drain.—Where a drain passes beneath a wall it should be protected against breakage by the insertion of a flagstone or iron lintel free of the pipe, or by a brick relieving arch.

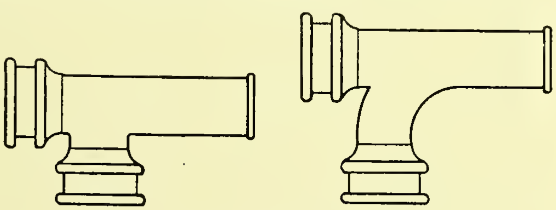


Fig. 612.—Junctions
No. 1, Square; No. 2, Curved.

Junctions.[1]—Right-angled junctions (No. 1, fig. 612), either vertical or

[1] See fig. 237, Vol. I, for other illustrations of junctions, bends, &c.

horizontal, are now forbidden by many codes of by-laws, which require every branch or tributary drain to join another drain obliquely and in the direction of the flow (No. 2).

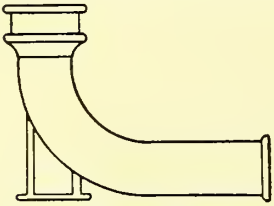


Fig. 613.—Bend with Foot Rest

Bends.—Bends fixed to receive a vertical soil or waste pipe should have a foot or support of the kind illustrated in fig. 613. Bends in the course of a drain should be made in inspection chambers, or should be fitted with air-tight covers, as illustrated in fig. 614. A small brick chamber can be built around the bend, or the earth can be filled in.

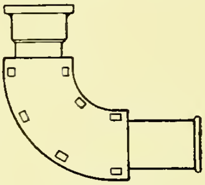


Fig. 614.—Access Bend

Drain Interceptor.—Most by-laws now insist upon the provision of an

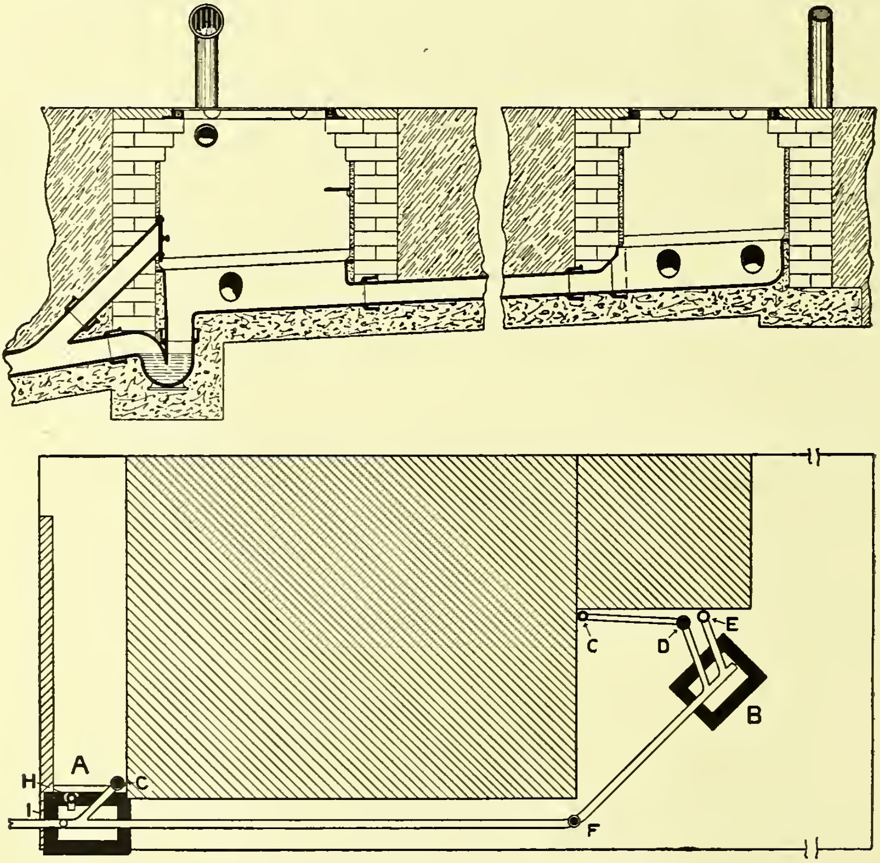


Fig. 615.—Drains for Semi-detached House with Forecourt

intercepting trap between the house drain and the sewer or cesspool. The position of this trap should be as near the boundary fence as possible. If the premises have not a forecourt, the trap ought to be fixed under the

footway, if the consent of the sanitary authority can be obtained; and, failing this, it must be provided inside the premises, a position which should only be adopted where any other course is impracticable. Fig. 615 shows a plan and enlarged section of the drain of a semi-detached house having a forecourt, and fig. 616 a terrace house where the front external wall abuts upon the footway, the drains in this case being of iron.

Inspection Chambers.—Access to the intercepting trap for the purpose of cleansing is now required by most by-laws, as well as to each end of a drain situated under a building. To provide the necessary access, it is

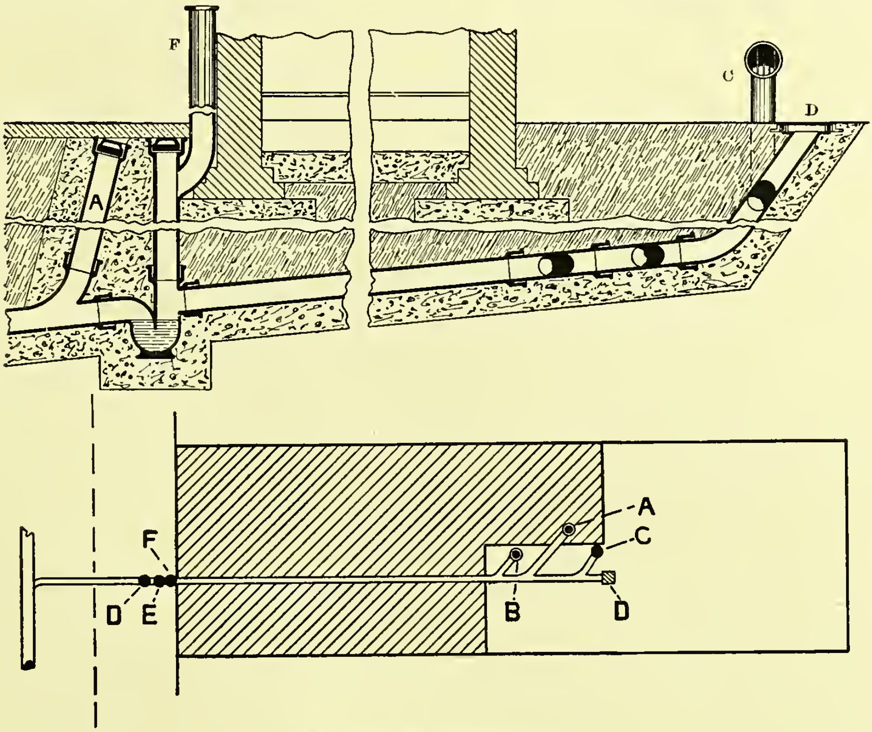


Fig. 616.—Drains for Terrace House

usual to construct an inspection chamber, in which the interceptor is fixed, the chamber being carried up to the ground level and fitted with a metal cover, as shown in fig. 615. A manhole should be sufficiently large to permit of proper access and the use of drain rods. For chambers less than 2 ft. 6 in. in depth, an area of 2 ft. by 1 ft. 6 in. ought to be the minimum, whilst for manholes of greater depth 3 ft. by 2 ft. or 3 ft. 6 in. by 2 ft. 6 in. must be allowed. For deep manholes, iron steps built into the brick-work at intervals, as shown in the section in fig. 615, are necessary.

A chamber is not always compulsory, and access is frequently provided in the manner indicated by fig. 616. A trap, E, having a vertical inspection eye is fixed, from the top of which a pipe is carried to the ground level and either covered by the paving as shown or by an air-tight iron cover. From this pipe the ventilating pipe, F, is carried up to a suitable height.

Sometimes a junction is placed on the outlet side of the trap with a sweeping arm brought to the ground level, as indicated at A in the section and at D in the plan. At the back of the premises a cleansing arm is arranged as shown at D, and a low-level ventilator at C. A and B are drain inlets. The access pipes at the front are fitted with stoppers, and the cleansing arm at the back has a small removable cover.

Every means of access to a drain is in London required to be water-tight up to the level of the adjoining ground surface or roadway. If the means of access takes the form of an **open-channel manhole**, it should be constructed of good sound bricks laid in cement, and rendered with cement $\frac{3}{4}$ to 1 in. thick, trowelled to a smooth face. Suitable cement benchings are also necessary, and the channel, if formed by a half-pipe only, should be deepened with one course of brickwork to prevent the sewage flowing over the benching.

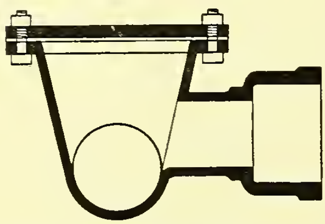


Fig. 617.—Sealed Drains for Manhole

A better arrangement for iron drains, and one which renders their adoption particularly useful, is that illustrated in fig. 617, which shows a **channel fitted with a sealed cover.** By this method the drain air is confined to the drain, and not allowed to disperse in the manhole. It also prevents any possibility of flooding; abolishes the opportunity for the deposit of offensive matter on the benchings, which is of frequent occurrence in many open manholes; and secures improved ventilation.

Stoneware channels for manholes are usually made in the half or three-quarter section shown in fig. 618. The latter is the better form for bends, as the extension on the outer side of the bend serves to direct the flow of the sewage.

Fig. 618.—Half and Three-quarter Channels

Covers.—A manhole having an open channel must have a suitable cover, which should—unless placed in an unfrequented spot—be air-tight. A York stone slab bedded on the brickwork is liable to work loose, and is neither so certain nor so convenient as one made of cast iron. In London, if a manhole is provided inside a building, an air-tight cover is compulsory. The simplest and cheapest description, shown in fig. 619, hardly deserves to have the term air-tight applied to it. The cover is generally bedded into the frame with grease, and for a time is perhaps air-tight; but more often than not these covers on examination are found to be unsealed.

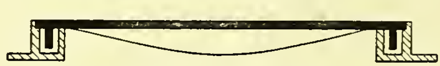


Fig. 619.—Ordinary Air-tight Manhole Cover

An air-tight cover, to be worthy of the name, should be so made that it will not only be in this condition on completion of the work, but will remain so permanently. Two good types of covers are illustrated in fig. 620. In No. 1 the cover is fastened down with screws on a rubber seating, and in the other the seal is permanently maintained, when

fixed to manholes with open channels, by the condensation that takes place on the under side of the cover, which is so shaped as to convey the condensed water into a groove, in which the inner rim of the cover dips to form a seal.

For manholes with sealed channels, as in fig. 617, an air-tight cover is not quite so essential, unless it is situated inside a building, in which case it would act as a second safeguard against the escape of drain air.

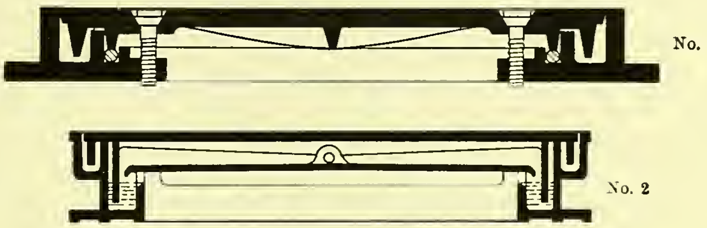


Fig. 620.—Good Types of Air-tight Manhole Cover

Ventilation to Drains.—Adequate ventilation is now considered indispensable, and is generally made compulsory by the local by-laws. To secure a constant movement of the air through the drain, at least two untrapped openings are essential, one to act as an inlet, and the other as an outlet. Under ordinary conditions it is best to provide the opening intended to act as an inlet as near the ground level as practicable, while that intended for the upcast or outlet shaft should be carried to as great a

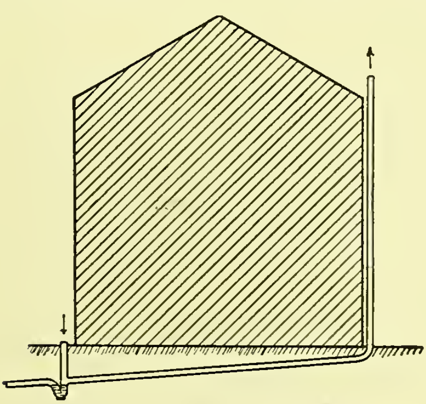


Fig. 621.—Drain Ventilation (First Method)

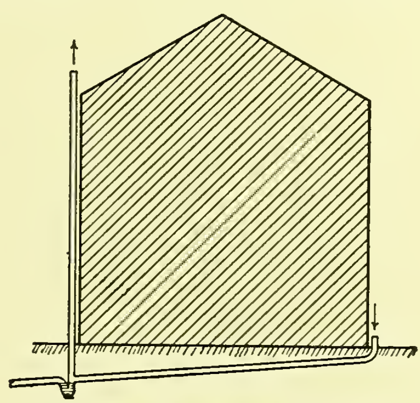


Fig. 622.—Drain Ventilation (Second Method)

height as possible, and should discharge in a position where the gases can be diffused without danger; but many codes of by-laws permit, as an alternative, the carrying up of two shafts to positions that, when either acts as an inlet, the other may be a safe outlet for foul air. The three generally accepted methods can be best explained by figs. 621, 622, and 623.

In fig. 621 are shown a pipe (intended to act as a fresh-air inlet) connected to the drain close to the intercepting trap, and a vertical upcast shaft at the rear of the premises. Fig. 622 illustrates a reversal of the foregoing

method, the fresh-air inlet being provided at the top end of the drain, and the upcast shaft close to the intercepting trap. This arrangement is preferred by many, as the normal flow of air through the drain is in the same direction as the flow of the liquid matters, thus accelerating the exhaustion of the foul air and the ingress of fresh air to take its place. The third method is indicated by fig. 623, where two shafts are provided to act either as inlets or outlets. In this arrangement an inequality in the height of the pipes should be aimed at.

The positions for the inlet and exhaust are at the extreme ends of the drain, and where long branch drains are present, and so situated as to be insufficiently ventilated by the means installed, special upcast shafts should be provided. In extensive drainage systems it is an advantage to sectionize the drains, fixing a reverse-action interceptor between the main and branch drains, with a fresh-air inlet and upcast shaft to each section. By so doing, the ventilation of each portion of the drain can be assured.

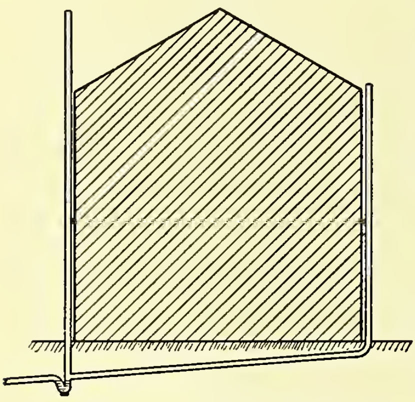


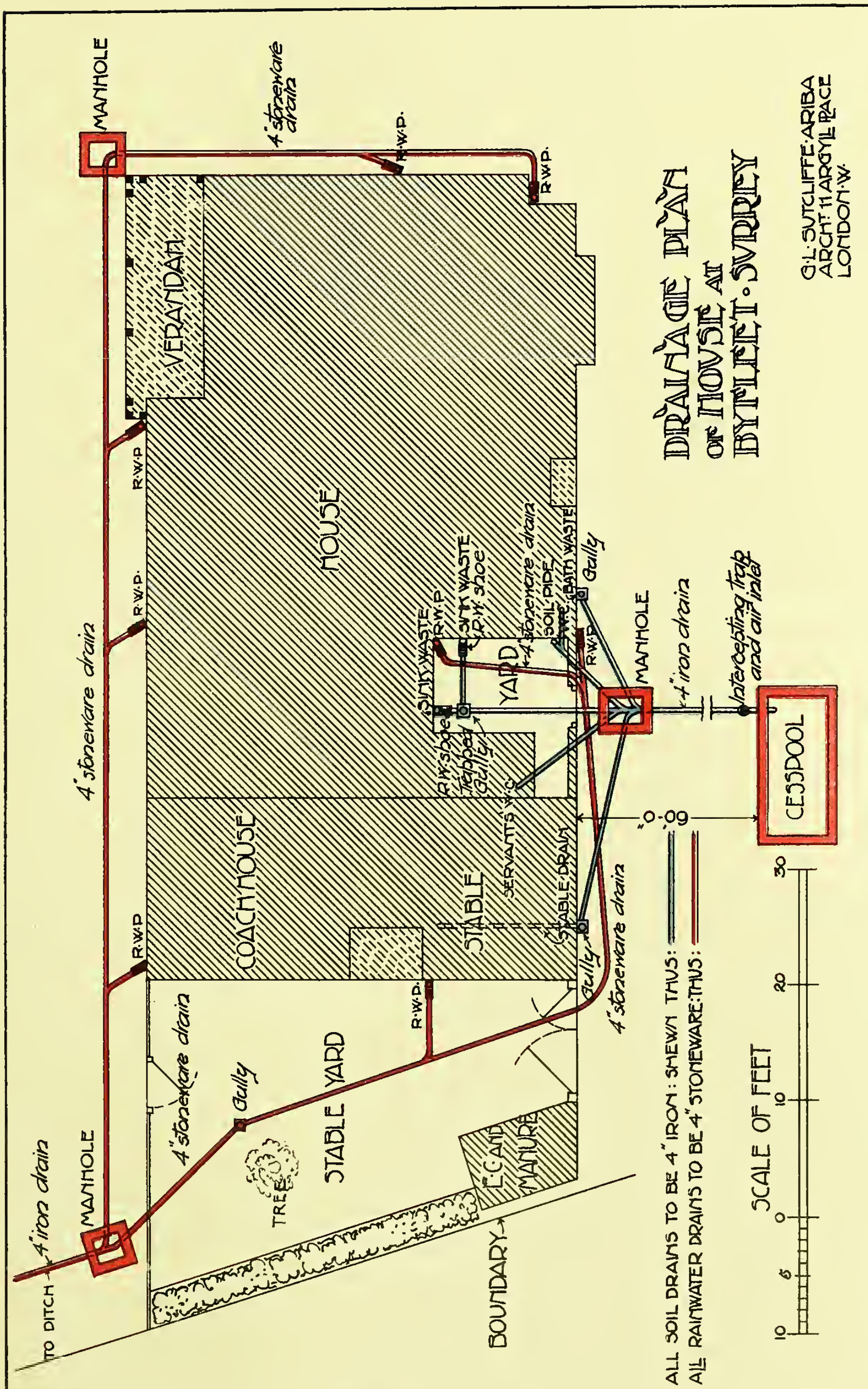
Fig. 623.—Drain Ventilation (Third Method)

Protection should be afforded to the ends of the inlet and outlet pipes by plain gratings (where they are within reach) or by domical wire guards, as shown in fig. 571. In any case the apertures must at least be equal in the aggregate to the internal area of the pipe. Fresh-air inlets are often fitted with mica valves with the object of preventing back draughts. They are, however, of very little utility, as they often become defective or fixed, and thereby useless. If a position at some distance from a building is possible, a plain grated inlet can be fixed just above the ground; but if attached to a building, it should be placed away from windows, so as to avoid possible offence from occasional puffs of drain air.

Flushing Tank.—If possible, the waste pipe from the bath should be connected at the head of the drain, as it will serve the purpose of a drain flusher. For small houses, special provision for flushing out the drains is not usually required; but for large systems, or for long lengths of drain having an inadequate fall, a flushing tank is very useful. It should be fixed at the head of the drain, automatic in action, and arranged so as to discharge at least once a day. It need not hold more than 75 gal. of water, and in many cases a smaller size is sufficient. A small tank, discharging at frequent intervals, is preferable to a large one which discharges but rarely. Suitable tanks are illustrated in figs. 568 and 608.

Traps, &c.—The size of ventilating pipes and the materials used in their construction have been alluded to in Chapter VII, and various traps for drainage work have been discussed in Chapter II.

Rainwater Connections.—Traps which receive rainwater only are particularly liable to being unsealed by evaporation in dry weather. It is


DRAINAGE PLAN
OF HOUSE AT
BYFLEET · SURREY
G·L·SUTCLIFFE·ARIBA
ARCHT 11 ARGYLL PLACE
LONDON·W.
ALL SOIL DRAINS TO BE 4" IRON: SHEWN THUS:
ALL RAINWATER DRAINS TO BE 4" STONEWARE: THUS:
SCALE OF FEET
10 5 0 10 20 30
HOUSE
VERANDAH
COACH HOUSE
STABLE
STABLE YARD
YARD
SERVANT'S W.C.
L'C AND MANURE
TREE
BOUNDARY
TO DITCH
4" iron drain
MANHOLE
4" stoneware drain
R.W.P.
Gully
Trapped Gully
R.W. shoe
SINK WASTE
SINK WASTE R.W. shoe
SOIL PIPE
W.C.
BATH WASTE
STABLE DRAIN
Intercepting trap and air inlet
CESSPOOL
60'-0"

therefore best not to provide a special trap at the foot of each rainwater pipe, but to connect the latter to a gully, which receives the waste water from a sink, bath, or other fitting. To carry this into practice sometimes involves a long length of drain between the base of the rainwater pipe and the gully. For the purpose of obtaining access, and to secure the ventilation of such a rainwater drain, a disconnector of the type illustrated in fig. 458 should be fixed.

Description of Drainage Plates.—Plate XXXIV shows a simple system of drainage for a detached country house in which the sewage drains and surface-water drains are kept entirely separate. The waste pipes from the scullery and pantry sinks discharge into rainwater shoes, from which shallow drains are taken to the back and side inlets of a trapped gully as shown. All the branch drains are collected in a single manhole, which is fitted with an air-tight cover in the usual way. The soil pipe is of cast-iron $3\frac{1}{2}$ in. in diam., and is carried up above the roof to serve as a drain ventilator. The ground around the house was raised about a foot above the original surface, and as a result the drain leading to the cesspool was so near the surface that no intercepting chamber was necessary; an intercepting trap is, however, provided with an air inlet about 6 in. above ground and concreted around. The sewage drains are of iron laid on concrete. The gully for the bath waste is a Stokes's gully with clearing arm and air-tight cover, and the gully taking the surface drainage from the channel in the stable is one of Winser's and has a perforated metal strainer. The surface-water drainage does not call for particular notice, but it may be pointed out that the out-fall drain was of iron, as it had to pass in the neighbourhood of a number of trees, and it was thought that the roots might ultimately find their way into a stoneware drain.

The drainage plan shown in Plate XII, Vol. I, was introduced principally to show the surface-water drainage of a large house and the tank for storing the rainwater. A few words about the sewage drains may, however, not be out of place, as the system is a kind of compromise between cost and efficiency. For example, at least two additional manholes might, with advantage, have been introduced in order to reduce the length of the branch drains; and in this connection it may be pointed out that the long branch drain from the bath waste on the left side of the porch to manhole No. 1 was added later, as originally it was not intended to provide a bath at that point. All the gullies are of the kind known as Stokes's, which are provided with clearing arms fitted with small air-tight covers, and so arranged that rods can be passed down the branch drains from the gullies. The two soil pipes serve in the usual way as drain ventilators. From manhole No. 3 there is a long out-fall drain leading to the septic tank, but an intercepting trap and air inlet are, of course, placed in the drain before its connection to the tank. All the sewage drains are laid on concrete and embedded in concrete to half their depth.

CHAPTER XI

TESTING SANITARY FITTINGS, PIPES, AND DRAINS

The four methods now generally practised in the way of tests for pipes and fittings are: (1) The olfactory, chemical, or smell test; (2) The smoke test; (3) The pneumatic test; (4) The hydraulic or water test. Each of these can be applied to both new and old fittings and pipes, whether soil or drain.

(1) *The Olfactory Test.*—The old-fashioned style of applying a chemical or smell test is to dissolve a small quantity of oil of peppermint, essence of cloves, or other odoriferous preparation in a pail of very hot water, and to pour the mixture into the top of the soil or ventilating pipe, the opening being at once closed by a wad of some description. Search is then made in the apartments where the sanitary fittings are situated, and in the neighbourhood of the drains, for any trace of odour from the test. Some engineers, however, prefer to empty the peppermint on to a piece of sponge suspended inside the soil pipe, and then quickly discharge over the sponge a quantity of hot water. In the use of free peppermint, or other pungent scent, it is necessary to prepare the mixture in the external air, the greatest possible care being exercised to prevent the smell being carried inside the premises through open windows and doors, all of which should be closed prior to the application of the test. This test is usually effective in discovering glaring defects, provided the pipes and fittings are exposed. For enclosed fittings and underground drains it is, however, unreliable, and for this and other reasons it is now seldom adopted.

An improved method of applying a chemical test is by means of glass tubes containing asafœtida or some other pungent preparation. Kemp's "Drain Tester" consists of a small phial containing a chemical preparation, and having a cover sealed by a piece of paper. A spiral spring is wound around the phial, and is slightly compressed by the paper seal. In applying the test a piece of string should first be attached to the loops provided, and tied to an adjacent fitting to prevent the phial and its contents being entirely carried away into the drain. The phial is then placed in a gully or the trap of a water closet, and washed through into the drain or soil pipe by a pail of water (hot, if procurable). On the water coming into contact with the paper seal the latter is softened, and is then broken by the spring, which forces the cover off the phial and allows the contents to be discharged. Before inserting the phial, all untrapped openings ought to be closed by a wad of flannel or other material. In ordinary cases, if defects are present, traces of the peculiar odour will be discovered in five to twenty minutes. Other well-known tests are those known as Banner's and Kingzett's, which are similar in principle to the above.

These volatile tests are useful for fittings and soil pipes, but are not absolutely satisfactory, either for exposed or covered works, as occasions are not unknown (particularly in testing old work) when the fumes have been carried away directly into the sewer and the result has been negative.

(2) *The Smoke Test.*—This method of testing is superior to the olfactory test, as it is visible in its action, discovering to the person conducting the test the approximate position of the leakage. It is applied in two ways—by means of smoke rockets or of a smoke-making machine.

Specially made rockets can be lighted and placed in a manhole, or into an opening made in one of the drain pipes; or a gully can be emptied, the rocket inserted, and a piece of board fitted to the orifice and bedded down with clay. A good form of rocket for fittings is that known as "Burnett's", which can be lighted and passed by means of a wire handle through the water contained in the trap of a water closet or gully. For a large drainage system several rockets must be discharged, and for a number of water closets on different floors one should be inserted in each trap.

A smoke test can be best applied by the aid of a generating machine, which consists of a chamber in which a fumigating material is burnt to produce smoke, the latter being then forced into the drain by a bellows or fan attached to the apparatus. The smoke cylinder is contained within a water jacket, into which dips the bottom of a metal dome. On the drain becoming filled with smoke, the dome is lifted by the pressure, and thus indicates whether the drain is sound. The great advantage of this machine over the rocket is that an internal pressure can be obtained. The test can be applied to a gully or drain in the same manner as a rocket, or special expanding drain stoppers, made to receive the rubber hose pipe attached to the machine, can be used. As it is easier for smoke to ascend than descend, the test is best applied at the lowest portion of the system.

(3) *The Pneumatic Test* is an air-compression test in which a pressure of 3 to 5 lb. is exerted upon the internal surface of the pipes. If the fumigating material is omitted, an ordinary smoke machine can be used, provided that sufficient weight is placed upon the dome to allow the application of the necessary pressure; or an air pump, somewhat similar to a cycle pump, can be used, with a recording gauge to show the pressure that is being applied. With this test it is necessary that all inlets, including ventilating shafts and fresh-air inlets, should be securely plugged with expanding or bag stoppers. The machine can be connected to one of the stoppers. While it is superior to both the olfactory and smoke tests, it fails to locate the leakage, and should not be accepted as infallible.

(4) *The hydraulic or water test* is the most reliable of all, and in the opinion of many experts the only one which should be accepted. Certainly when a certificate is to be issued, nothing short of the application of this test should be considered sufficient.

In the testing of drains, it is usual to plug the lowest end with a bag or expanding stopper, and charge the pipes and manholes (which also require to be watertight) from the various traps and fittings. With the branch drains considerable difficulty is often experienced in getting rid of the air which becomes compressed in the higher portion of the pipe. If an access hole is provided on the outgo side of the attached gully, the stopper should be removed, when the drain will easily fill. If this convenience does not exist the trap should be emptied, and a piece of lead, compo, or rubber hose pipe bent so that one end is outside the trap and the other at the top of

the trap outgo. This will relieve the air compression and allow the drain to fill. With stoneware drains the test should not be applied until at least twenty-four hours after the cement joints have been made. With iron pipes the test can be applied immediately on completion. Stoneware pipes and the cement rendering of manholes absorb a quantity of water, owing to the porosity of the materials, and allowance must be made for this. After charging, the drains should be permitted to remain for two or three hours, and if the water level is maintained, they can safely be passed as sound.

Soil pipes are most conveniently tested in sections and before being connected to the drain. A stopper should be inserted at the foot of the pipe, and the latter filled up to the lowest fitting. This should then be plugged and the next section charged, and so on until the ventilating shaft is reached, which must be filled from the top. In new work, lofty stacks of lead soil pipe should be tested in sections, commencing at the top; by so doing the lower portion is not subjected to too great a strain. In practice, it is only necessary that the soil pipe should be of sufficient strength to resist the pressure exerted if the pipe is charged up to the level of the lowest fitting. Iron pipes possess much greater strength and can be tested as a whole. Waste pipes can be tested in a similar manner to soil pipes.

Objection is sometimes urged against the use of the hydraulic test on account of its severity, particularly for old drains; but for new work it is not one whit too severe, as any stoppage of the drain will cause the test to be automatically applied. For old work a little laxity is perhaps permissible, and if the leakage is of a minute character, the drain need not relentlessly be pulled up, if situated outside the premises. If, however, it passes under the house, the defect should be remedied. In the event of the water escaping rapidly the drain can only be regarded as defective.

The by-laws in force in London require all new drains to be capable of withstanding a pressure equal to a 2-ft. head of water, which is a mild test, as, at the head of the drain, this would mean a pressure of less than 1 lb. per square inch. It must be remembered, however, that the lower end would be tested more severely according to its depth. Even for the joints of stoneware drains this cannot be considered excessive, as a well-laid drain should be capable of resisting a pressure of 5 to 6 lb. per square inch. Nevertheless a stoneware drain ought not to be tested in conjunction with a soil pipe which is filled up to a height of 20 or 30 feet above the ground, thereby subjecting the drain to a strain of 8 to 12 lb. per square inch. Iron drain and soil pipes can be tested up to between 50 and 100 lb. if properly jointed, but a pressure of 6 to 10 lb. is usually regarded as sufficient. Definite and reliable data are not obtainable as to the safe strength of lead soil pipes, but it is computed by one authority that the pressure applied should not exceed 15 lb. per square inch.

CHAPTER XII

NOTES ON SEWAGE DISPOSAL

Sewage produced by communities is disposed of by one of the following methods:—

(*a*) By the discharge of the crude sewage into the sea, tidal rivers, or running streams.

(*b*) By broad irrigation.

(*c*) By intermittent downward filtration.

(*d*) By chemical treatment in tanks (precipitating the solids) and the filtration of the liquids.

(*e*) By treatment in septic tanks and subsequent filtration, &c.

Any of these methods can be adopted for the disposal of sewage from an isolated house in the same manner as for communities, but, of course, in a modified form.

(*a*) While under certain conditions crude sewage can be passed directly into the sea, its discharge into a watercourse or stream is now an offence; it not only pollutes the water, but is frequently provocative of nuisance by the deposit of offensive silt on the banks.

(*b*) *By broad irrigation* is meant the distribution of a thin film of screened sewage over a large tract of land used for agricultural purposes. The usual method of application is to convey the sewage by means of open channels or carriers to the selected site, and discharge it over the surface or into furrows. The soil should be fairly light and pervious, but gravel or sand is not suitable, as the liquid drains away before it can be absorbed by the vegetation. On the other hand, clay or heavy soil is unsuitable, as it retains the liquid for too long a period. The purification is principally effected by bacteria, the organic impurities being split up, part being given off in the form of gases, another part being absorbed by the vegetation, and the solid mineral matter being retained in the soil.

(*c*) *Intermittent downward filtration* is somewhat similar, but for this method sufficient subsoil drains must be provided. These are usually laid about 6 ft. below the surface, the distance apart being regulated by the nature of the soil. The surface is either prepared in butts about 30 ft. in width, having a fall from the carrier from which the sewage is discharged, or is ridged and furrowed. Before discharging the sewage into the carriers it is passed through a strainer, which retains the large solids. Similar land is required as for surface irrigation, and with both systems it is usual to have at least two plots, which can be worked alternately.

(*d*) *Chemical or artificial purification* consists of precipitating the solid matters in tanks by the aid of a medium which is also a deodorant. The most commonly used precipitants are lime and sulphate of iron, about 4 grains of lime and 1 grain of the sulphate being added to each gallon of sewage, which is first passed through straining chambers to arrest the large solid matters. This method produces a large quantity of sludge, which is

compressed into cakes, or run off into a settling pond, whence, after drainage, it is cut out and used as manure.

Although the precipitant clarifies the sewage, it does not to any extent purify the liquid portion of it. To effect this the effluent is aërated by passing it over "tumbling" bays, and is then filtered through the land in one of the ways described above, or (if suitable soil is not available) through artificial filters formed with coke breeze or other material.

(*e*) *In the septic tank or bacterial system* of purification the impurities are to a large extent removed by the action of the micro-organisms present in the sewage. For treating the sewage from a mansion or other isolated building by this system, a septic tank large enough to hold one day's flow of sewage is required, with an adjacent contact bed, or a percolating filter, formed of clean hard clinker or coke.

The sewage is first passed through a strainer and then run into the septic tank, which is either made air-tight by a close cover, or is rendered so by the scum which forms on the surface. As a certain amount of smell is inseparable from this stage of the process, a covered tank is desirable for private installations, with a ventilating shaft 10 or 12 ft. high. In this tank the sewage is subjected to the action of anaërobic organisms.

From the septic tank the effluent is discharged on to a contact bed containing clinker or coke breeze, and is further purified by aërobic organisms. The sewage is retained in the bed for some hours, an apparatus being installed by which the duration of the contact can be regulated and the "filtered" sewage automatically discharged. The contact bed is usually about 3 ft. deep, but better results are obtained by means of a percolating filter from 4 to 6 ft. deep. This filter may be built with rough stone or flint walls (without mortar), enclosing the coke or other filtering material; the effluent from the septic tank is discharged in small quantities at frequent intervals in such a manner that it is distributed in drops or fine sprays over the surface of the filter, and passes through it to the concrete floor, which is laid to slope to the outfall channels. The advantage of this method is that the filter is never water-logged, and consequently there is always an ample supply of air, without which the bacteria cannot properly purify the sewage.

Section IX

MECHANICAL AND PNEUMATIC BELLS AND SPEAKING TUBES

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Section IX

MECHANICAL AND PNEUMATIC BELLS AND SPEAKING TUBES

CHAPTER I

MECHANICAL BELLS

The crank-and-wire bell system of communication between various rooms or points at moderate distances apart has been in general use for a great number of years. It has, however, during late years been to a considerable extent superseded by pneumatic and electric bells, special advantages being claimed for each of these systems. While in the majority of modern buildings of any pretensions the electric-bell system has been, or is being, introduced, there are still a number of the older houses and establishments fitted with crank or mechanical bell installations, and at a trifling cost these may be kept going for a number of years, although the system can readily be exchanged for the electric, if considered desirable. When desired, existing mechanical pulls of an elaborate design can be turned into electrical pulls by means of what are termed connectors. Some persons, however, even for new houses, are inclined to give preference to the mechanical system.

Bad materials and workmanship bring discredit on both systems alike, and unless these can be efficiently guarded against during construction, satisfactory results in working can never be ensured. With the best materials and fittings, coupled with good workmanship, there is no reason why a crank-bell system, within certain limits, should not give satisfaction equally as well as an electric-bell installation.

While the crank-bell system may not be considered so suitable for the requirements of large establishments, such as hotels, offices, or other institutions, it has certain advantages when fitted up on a small scale. Unless by the sudden snapping of a wire through an extra strain being brought to bear on it, the system may go on for years without requiring the slightest attention. Partial failure may result occasionally, owing to the gradual stretching of some of the wires, causing slackness and consequent non-ringing of the bell at times, but this defect can usually be more or less easily rectified. When the work has been efficiently carried out in the first instance, there is little danger of this failure occurring through the stretching of the wires. The experienced bellhanger can easily tell by the feel of

the wire when it has reached its natural stretching limit, and this should be ensured at the time of fixing.

The principle of a crank-bell installation is that a wire or cord of some description is fixed between two points, a pull or handle being attached to one end and a bell to the other. When the handle is pulled at one end of the line the bell is rung at the other end. The points at which the pull and bell are fixed may be in separate rooms on the same, or on different, floors of a house, office, or other establishment.

Wiring.—Although these points may both be on the same floor, certain changes in the direction of the wire are unavoidable, and these are effected by means of cranks of various design, or in certain positions by chains acting over wheels or pulleys. Usually in a small installation the wire is taken as directly as possible between the two points, and this may also be the case where communication is desired between the dining or drawing rooms, or one or more bedrooms, and the servants' department. Where, however, there are a number of rooms on the various floors of a building, from each of which means of communication is desired, it will generally be found better practice to carry the whole of the wires as directly as possible from the pulls up into the roof space or upper portion of the building, and there to "bunch" or collect them together at a point from which they can be led directly down to the room where the bells are hung. This system is usually considered preferable to that of dealing with each floor separately. When the wires are taken up into the roof it will generally be found easier to deal with them in the case of renewal or repairs, and it will also probably be found that fewer cranks will be required. Each case, however, should be considered on its own merits. Under ordinary circumstances the extra cost of the additional wire required by the overhead system will be compensated by the saving in cranks, &c. The latter also are often very difficult of access when anything goes wrong. Much will depend on the height of the building or the number of stories, and the facilities for grouping the wires by floors.

Tubing.—In common work the bell wires may be exposed to view, but in work of a better class it is usual to enclose them in tubes buried in the plaster, the pulls or levers only being exposed in the rooms. The disadvantage of encasing them in plaster is that they are difficult to get at for repairs or alterations without doing damage, unless the new wires can be threaded through the tubes whilst in position. As in electric-bell work it is easier and more satisfactory to arrange and fix the tubes and some of the wires before the plastering and joinery are done.

In fitting up an existing building a good deal of damage must necessarily be caused by cutting through walls, ceilings, cornices, &c., more especially when lever pulls are to be fixed and the wires concealed by tubes in the plaster. Hence the frequent use of loose pendent lines, cords, ropes, or ribbons, fitted with suitable pulls or handles, where exposed in the rooms, thus reducing to a minimum the necessity for cutting into the plaster. The loose line is usually carried up close to the ceiling, where it is either attached to a wire continued in a vertical direction or to a lever pull or crank, if there is a change of direction. The wire can be carried

along the angle between the wall and the ceiling, or in the cornice, if there is one, and in either case it should be properly supported at intervals by suitable staples, which, while preventing sagging, allow perfect freedom of movement. Should the wire be run in tubing, the latter should be secured by suitable wall hooks or clips, and would look like an exposed gas pipe. When the wire has to pass through a wall, a hole must be cut or bored, and a tube provided to receive the wire, together with cranks of a suitable form whenever there are changes of direction. Occasionally it may be found practicable to run the wires alongside a floor joist, to which also the necessary cranks would be attached; or by taking up a floor board the wire can be run underneath in a series of notches cut in the joists. This board should be screwed down, or at any rate that portion of it which fits over the crank, so as to admit of ready access for inspection or repairs.

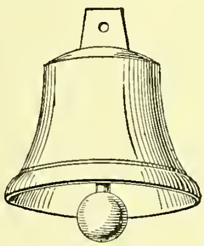


Fig. 624.—House Bell with Turned Edge

Mechanical bell fittings consist of the bells themselves, a wire or wires, tubing to contain the wire when considered desirable, bell pulls, levers or handles for the operator to work, cranks or wheels and chains where there are changes of direction of the wires, carriages and check springs for connecting the wires to the bells, and usually a board on which the bells are hung.

House bells of the ordinary pattern (fig. 624) are generally composed of one of tin to three or four of copper, the usual sizes being 3 in. and 3½ in.,

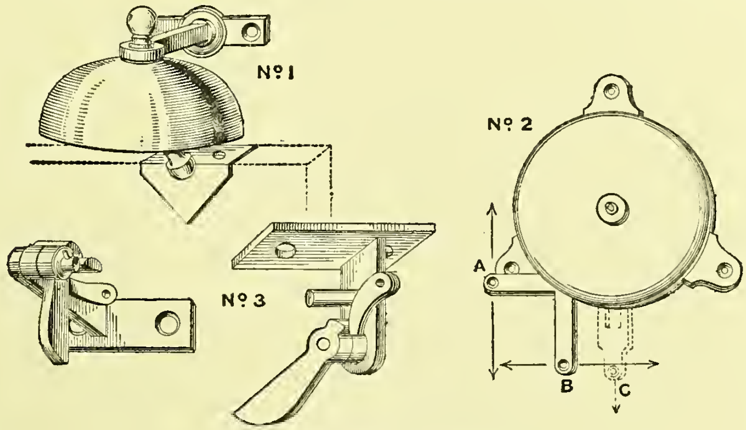


Fig. 625.—Shop-door and Alarm Bells

but for certain purposes 2½-in. and 4-in. bells may be used. They are sometimes described by weight, such as 6, 8, 10, or 12 oz.; also as being of first, second, or third quality, according to the tone and the degree of finish, the ordinary quality having turned edges only, those of the best quality being turned and lacquered.

Shop-door and alarm bells (fig. 625) of various patterns, with or without springs, are obtainable in sizes ranging from 2½ in. to 9 in. Some of these are set in motion, on the opening of the door, by means of a catch or trigger,

or merely by the top of the door moving the hammer or clapper, which is released when the door has opened to a certain angle (No. 1). Others are set in motion by means of wires and levers, and may be at a considerable distance from the door which operates them. No. 2 shows an alarm bell, having levers A and B arranged to pull up and down, or right and left, as shown by the arrows, according to the position it is intended to occupy. Similar bells are supplied without the double levers, but with a single pull arm (as shown by the dotted lines at C), which acts as a spring. The provision of the levers or arms enables these bells to be hung at a distance from the doors actuating them, in some favourable position, where they can readily be heard by the occupants. Wires are run by means of the necessary cranks, &c., from the bells to a catch or trigger, which, on being moved by the opening door, sets the bell in motion. Whether the bells themselves or the triggers are acted on directly by the door, they should be so fixed as to come into operation when the door begins to open. This precludes any attempt being made by an outsider to open the door gently until he can reach the apparatus and prevent the bell from ringing. Double-action door alarm bells are also supplied, which will ring both on the opening and the closing of the door.

Bell boards are usually from 9 in. to 11 in. in depth, and from $\frac{3}{4}$ in. to 1 in. in thickness, having chamfered, beaded, or moulded edges, and may be painted, varnished, or polished, according to the class of wood used and the surroundings. They should be long enough to give ample space for the cranks and bell carriages of each bell to be fixed, so that they will not interfere with each other whilst in action. The bell carriages are generally fixed about 9 in. from centre to centre. As the strain on such a board is considerable if a large number of bells are attached to it, care is necessary to see that it is securely fixed, either by being screwed to a wooden partition or grounds, or by nailing to plugs driven into the joints of the brick or stonework.

The bells or the board immediately behind them should be numbered or lettered to indicate the room with which each is connected. Sometimes a pendulum, with label, is attached to the bell-carriage arms, which, by vibrating much longer than the ordinary bell, gives the person whose duty it is to attend the call a better chance of knowing where his presence is required, in case he may have been temporarily absent or out of hearing when the bell was rung.

When a number of bells are hung close together, the front-door bell should be of a distinctly different tone from the others, so that when rung it will indicate to all concerned from what point the call comes. The other bells may also be selected of varying tones, so that they can in time be distinguished from each other.

Bell wire of best-quality drawn copper should be specified for all good work, the gauge usually adopted being No. 14 for outdoor and No. 16 for indoor work. Occasionally for first and second qualities Nos. 16 and 17 gauges are used, and No. 18 for third quality. Copper wire is less affected by damp, &c., than iron wire. It should be well stretched before fixing; otherwise it will sooner or later require tightening up to prevent failure

owing to slackness. This defect can sometimes be remedied by a handy householder undoing the wire at the joints where exposed, or at the connection to cranks, &c., and then tightening up until the slackness disappears. It is advisable, however, to employ an expert when anything goes wrong, especially when the system is in any way complicated; otherwise there is danger of the whole run being thrown out of action. A certain amount of skill is required in squaring up the cranks when wiring, or taking in the slack between two points, to prevent over or under draft, either of which is detrimental to satisfactory working.

When not enclosed in tubing, horizontal wires require support at intervals to prevent sagging, and this should be carried out in such a way as to allow perfect freedom of movement for the wire. Staples (fig. 626) of various descriptions, square and round, are used for this purpose as well as for the fixing of the tubing, and are obtainable in lengths varying from $\frac{1}{2}$ in. up to 1 in. or $1\frac{1}{2}$ in., and either tinned or coppered.

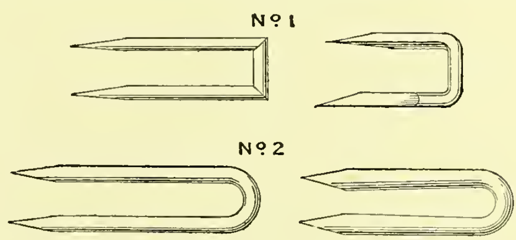


Fig. 626.—Staples

In buildings containing a large number of bells the wires, instead of being enclosed in tubing, are generally carried vertically down from the roof to the bell board in a chase or groove, and are spaced about $\frac{1}{2}$ in. apart, something like the strings of a harp. The deal front or casing of this chase should be fixed with screws, so as to be readily removable for inspection or repairs to the wires.

Tubing to contain and protect the bell wire is usually of zinc, $\frac{1}{4}$ in., $\frac{5}{16}$ in., $\frac{3}{8}$ in., $\frac{7}{16}$ in., $\frac{1}{2}$ in., or $\frac{5}{8}$ in., and occasionally for special purposes $\frac{3}{4}$ in. or 1 in. in diameter. It should be of stout quality, securely fixed to the walls or partitions, &c., by means of staples, holdfasts, or clips, in such a way as not to injure the tubing by being driven too hard against it. In very common work the zinc tubing is secured in position by driving nails in at intervals on alternate sides of it. If the bore is reduced, free movement of the wires may be hampered, and the wires may be cut or jammed against the disturbed edges of the longitudinal joints. Copper tubing is sometimes used when exposed in important positions, and galvanized wrought-iron gas tubing and steel conduit tubing as used for electric-lighting purposes, are often specified for first-class work. These are more expensive than zinc, but are stronger and more durable.

When a number of wires are required to be run in the same tube, the diameter of the latter should be ample, to prevent the wires from interfering with each other. Some bellhangers adopt the following table as regards the number of wires, and the diameter of the tubing to contain them:—

Diameter of tube in inches ...	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$
Number of wires	1	2	3	4	5	6

These may vary slightly; for instance, two wires may sometimes be run

in a $\frac{1}{4}$-in. tube, but it is better to err on the safe side, and the numbers quoted should not be exceeded.

As already explained, where there are a large number of wires to be run from the roof to the bell board, it is usual to enclose them in a chase

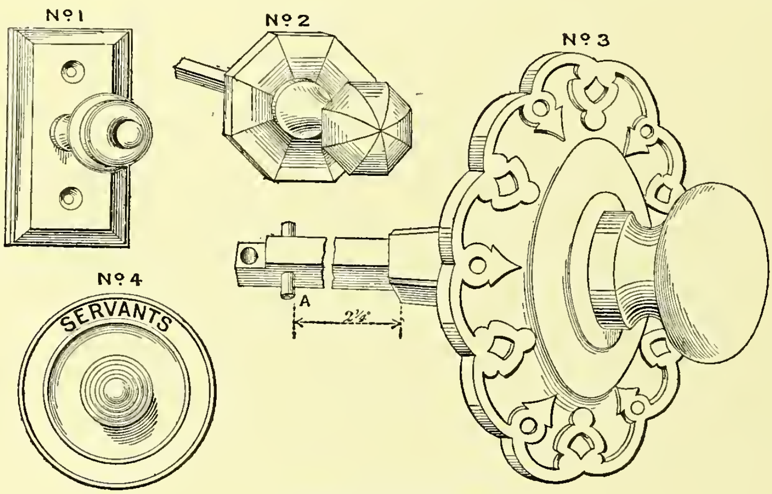


Fig. 627.—Draw-out Pulls

fitted with a movable front, in which case the single wires only from each pull or lever up to the roof would be enclosed in tubing where necessary.

In some cases it may be found convenient to provide bells with horizontal instead of vertical arms, and to fix them on the bell board in pairs, carrying up the two wires in one tube to their respective single cranks fixed to a crank board in the roof.

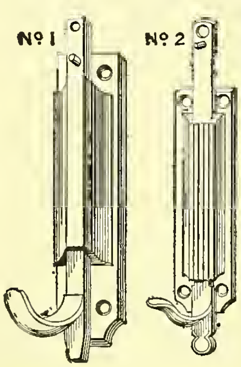


Fig. 628.—Slide or Bolt Pulls

Bell pulls and levers, &c., are usually of the draw-out (fig. 627), slide (fig. 628), pendent (fig. 629), quadrant (fig. 631), and lever types (figs. 632 to 634), or with handles for cords or ribbons (fig. 635). They are formed of various materials and in a variety of designs to suit the character of the building or room in which they are to be used. For external use they may be of iron, steel, or cast or wrought brass, either plain polished and lacquered, or bronzed and relieved in various patterns.

Various forms of straight **draw-out pulls** are shown in fig. 627. The knobs for draw-out pulls may be of iron, brass, copper, bronze, china, cut glass, &c., and may either project from the plate (Nos. 1 to 3), or the plate may be sunk or dished, forming what is termed a sunk or sunk-dish bell pull (No. 4). The plates may be marked "Visitors", "Private", &c., as may be required. The spindles, which are generally of iron or brass, are connected either directly to the bell wire, or by means of a crank, or wheel and chain, where a change of direction is necessary. A pin (A, No. 3) passing through

the spindle prevents it from being drawn out too far, or too great a strain being applied to the wire. Similar stops are fitted to slide and pendent pulls.

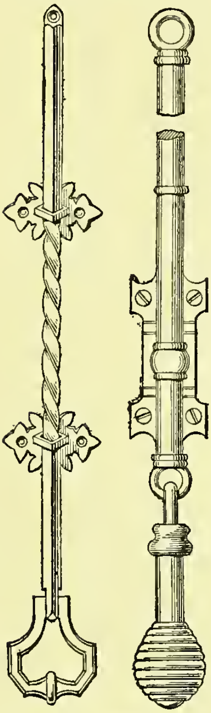


Fig. 629.—Pendent Pulls

Slide or bolt pulls of light, medium, and strong quality are supplied of different patterns, two of which are shown in fig. 628.

Pendent pulls, of which there are a great variety of designs, are shown in fig. 629.

Where the wires or chains from vertical pulls (figs. 628 and 629) change direction or pass through a wall, or by the side of a doorway, a spring crank is usually introduced of a pattern similar to fig. 630.

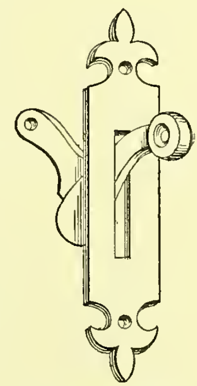


Fig. 630.—Spring Mortice Crank

Quadrant pulls (fig. 631) are also provided with springs or with wheels and chains for connection to the wires, suitable for either a horizontal or vertical pull, the latter being either ascending or descending. Nos. 1 and 2 show two different forms with projecting handles, and No. 3 is a flush quadrant pull fitted with wheel and chain.

The pulls above described are chiefly used for external work, being fixed at the sides of the entrance doors. Flat and sunk plate pulls of various designs in iron or brass are supplied by many makers, also ornamental gate pulls in iron and bronzed or polished brass. A special form of malleable-iron pull is sometimes used at entrance gates, suitable for attaching to a stone pier or iron railing. When there is a long stretch of wire between (say) a

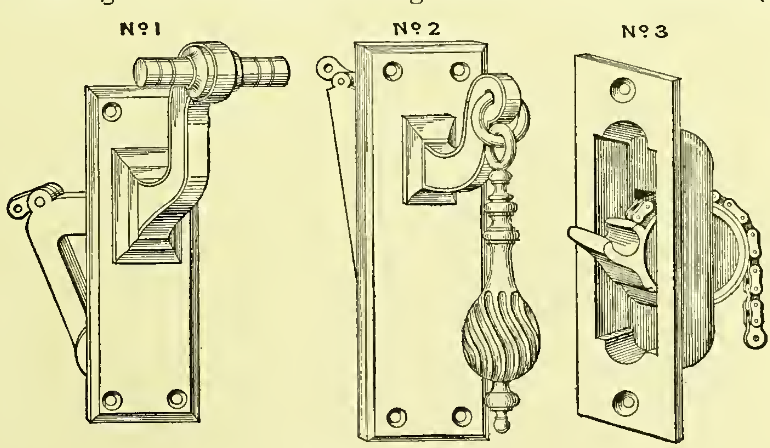


Fig. 631.—Quadrant Pulls

front gate and the house bell, the strain on the spring is greatly reduced by fixing a balance weight about the middle of the length.

Bell levers (figs. 632 to 634), like the pulls already described, are supplied in a great variety of materials and patterns, and are chiefly used indoors. The exposed portions may be entirely of brass finished in various ways, or with brass levers and mountings of boxwood, china, ebony, or cut glass to match adjoining fittings. The box and chain drum, being hid from view, are usually of cast iron. No. 1, fig. 632, shows an ordinary form of lever for fixing to a wall when the wires are concealed behind, and No. 2 a type used for fixing in bedrooms, &c., high up on the walls (sometimes close to the ceiling), where the change of direction occurs, the lever being acted on by a cord.

There are various methods of fixing bell levers according to their position, special forms being those provided with Aberdeen and Glasgow backs, the latter (fig. 633) having iron or brass boxes and rings, which enable a secure fixing to be obtained.

Lever pulls are sometimes sold in pairs —"handed", as it is termed—to move right

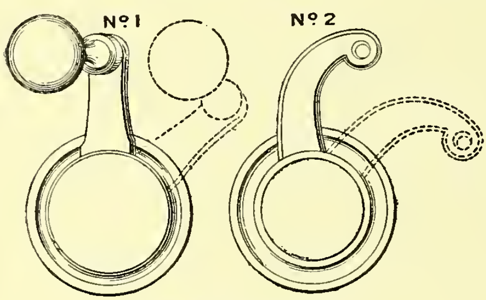


Fig. 632.—Lever Pulls

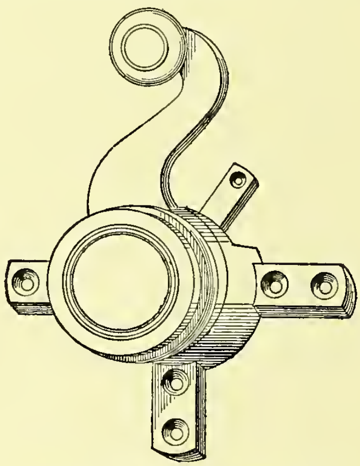


Fig. 633.—Lever Pull with Glasgow Back

or left, according to the position they occupy when fixed. In the case of a room having a lever pull on each side of the fireplace, the rule to be observed is to fix them so that the levers in each case shall move away from the fire, whether operating a rising or a falling wire. By a little manipulation—which will presently be explained—any lever, at any rate those of the straight-armed pattern, can be fixed so as to move in either direction.

Fig. 634 shows the mechanism of an ordinary lever pull to move to the left, and acting on a falling wire. A (Nos. 1 and 4) is a sunk casting, or *box* as it is termed, having a spindle riveted or otherwise secured through its back, as shown in the section (No. 4). It is screwed to a wood block fixed in the wall. The chain drum B (which is also a casting) is slipped over the spindle, which it fits quite loosely, and the linked chain, one end of which is secured by a small screw to a boss formed for it on the inner edge of the drum, is passed over the top of the drum and through the slot formed in the box, where it is ready to be attached to the bell wire. The two holes *a a* on the end of the drum (No. 2) are for receiving the screws which secure the lever arm D in position (Nos. 3 and 4). In

some patterns the lever arm is secured by one screw only—the upper one, —shoulders or lugs being formed on the outer edge of the drum between which the lever arm fits. This arrangement enables the drum to be easily rotated by the arm as required, but the system of fixing by means of two screws is that usually adopted. Before fixing the lever arm, the outer rim or detached ring C (Nos. 3 and 4), which forms the base of the rose, is placed in position and secured by two studs which fit into the slots or notches *b b* (Nos. 1 and 2), formed on the outer rim of the box casting.

The ring C has a projecting rim around a portion of its inner edge, the ends of the projection at *c* and *d* (No. 3) forming stops which prevent the lever arm from going beyond certain limits — generally about one-third of the circle. When in its normal position the lever arm is vertical, being stopped against the projecting edge of the rim at *d*, so that it can only move in one direction. If intended to be used as a left-hand lever, the rose base C should be fixed with the stop as at *d* (No. 3), so that the lever can only move to the left, as shown by dotted lines (D_1). If intended to be right-handed, the rose-base ring must be fixed with the stop or shoulder *c* against the left edge of the lever arm, so that the latter can only move to the right.

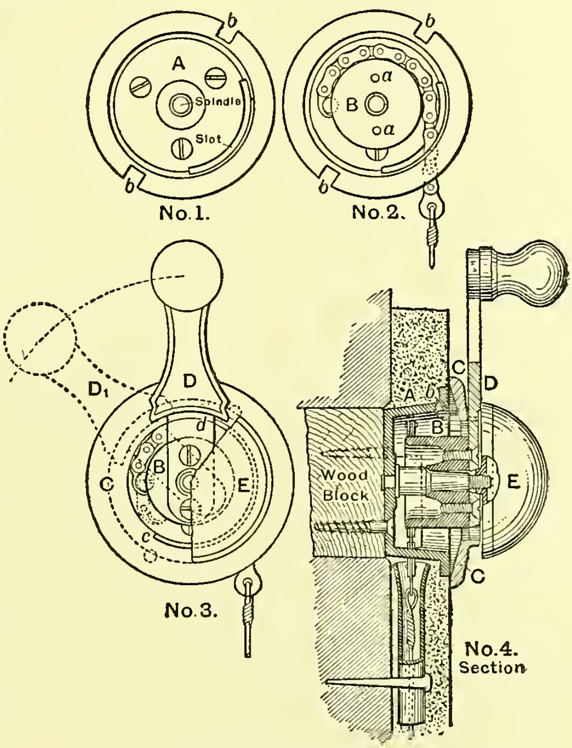


Fig. 634.—Details of Bell Lever

No. 1, Cast-iron box; No. 2, Box, drum, and chain; No. 3, Front with part of rose removed; No. 4, Section.

The fitting is completed by screwing on it the top of the rose E, which in this case may be considered to be of china or porcelain enclosed in a brass casing provided with a boss at the back for receiving the end of the spindle screw. By unscrewing the top of the rose at any time, the mechanism can be inspected, and, if necessary, the lever arm can be detached, the base ring removed, and the drum and chain withdrawn, to see that the joint between the chain and wire is sound. If, as sometimes happens, a chain link breaks, it may be necessary to disconnect the wire from the next crank to enable it to be withdrawn sufficiently far to allow a new or the repaired chain to be connected to it. If the detached end of the wire at once enters a tube, it is advisable to connect temporarily to the

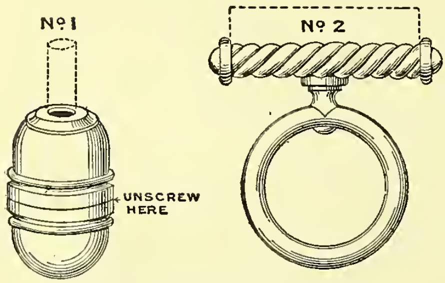


Fig. 635.—Handles for Cords and Ribbons

free end another wire or cord, so that it can be drawn back and tightened up after the new joint to the chain has been made good; otherwise it may be difficult to thread the wire back after attaching the chain. The movable parts of the fitting are again easily replaced.

As already explained, the lever pull shown in fig. 634 is fixed as a left-hand lever; but by shifting its position to the other side of the fireplace it could be used as a right-hand lever to act on a rising wire. The direction of the chain over the drum

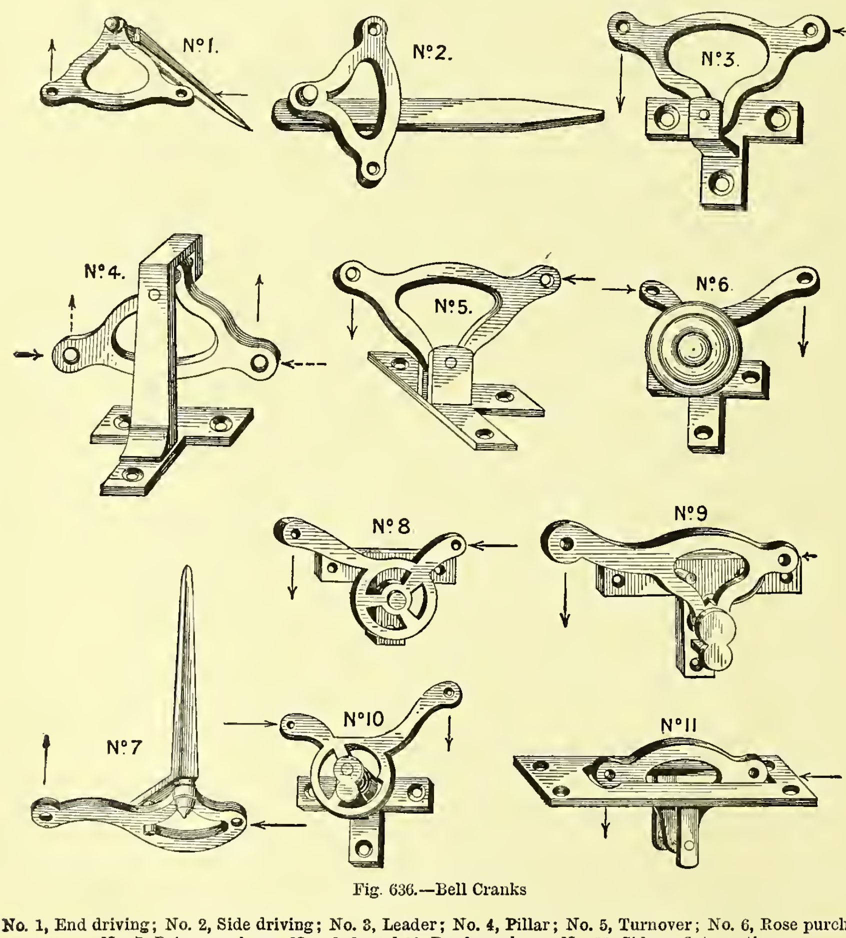


Fig. 636.—Bell Cranks

No. 1, End driving; No. 2, Side driving; No. 3, Leader; No. 4, Pillar; No. 5, Turnover; No. 6, Rose purchase; No. 7, Drive purchase; Nos. 8, 9, and 10, Roof purchase; No. 11, Side or flat mortice.

would be reversed, passing under instead of over, and care has to be taken in fixing the box to see that the slot is so placed that the chain can work

freely through it, according to the direction to be taken by the wire to which it is attached. It follows, therefore, that a straight-armed lever can be fixed either right or left hand by arranging the box, chain drum, and base ring of the rose in suitable positions. With bent, curved, or cranked-arm levers, however, such as those shown in No. 2, fig. 632, and in fig. 633, it is necessary to order them handed for particular positions, as the levers are intended to move in one direction only.

The mouth of the tubing to contain the wire and chain should be brought close up under the box, to enable the plaster to be made good round it, as shown in No. 4, fig. 634, and should be opened out slightly, or made trumpet-shaped, so as to allow the joint between the chain and wire to move freely without risk of catching on the sharp edges of the mouth. which in any case should be rounded off.

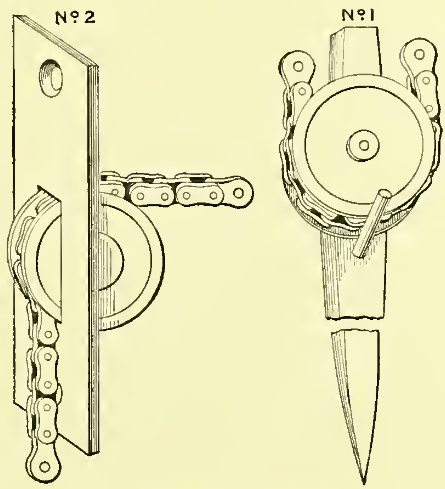


Fig. 637.—Chain and Wheel Cranks
No. 1, Driving; No. 2, Mortice.

Handles of some sort are occasionally used in places such as bedrooms, where, instead of wires, exposed cords or ribbons are employed as lines. With a worsted line the handle may simply be formed by a loop in the line itself, by a tassel to match, or by what is termed an egg pull, which may be of bone, ebony, china, brass, or ivory, the lower portion being removable to enable the knot to be concealed in the interior. No. 1, fig. 635, shows a form of handle suitable for a bell rope or cord, and No. 2 the kind required when a ribbon is used for the line.

Cranks of various forms (fig. 636) are required where changes of direction occur in the pull or line of wire. Like the other fittings these are of different qualities, finish, and degrees of strength according to the position in which they are to be fixed, whether conspicuous or otherwise, and suitable for driving into walls, &c., or for being screwed to woodwork. The simplest are those attached to spikes, and suitable for either end driving (Nos. 1 and 7) or side driving (No. 2). Leader, pillar, turnover, and spring purchase cranks of various patterns are shown in Nos. 3 to 10, each having only one crank or "fly". These cranks, however, can be obtained with two, three, or more flies, according to requirements (fig. 641). A side or flat mortice crank is shown in No. 11. The arrows show the direction of the pulls.

Chain and wheel cranks, for use where the change of direction is at an acute or obtuse angle, are shown in fig. 637. The chains are usually single, as shown, but can be obtained double when extra strength is essential.

A good deal of judgment is required in setting out and in arranging the cranks, so as to give full draft by cross wiring and otherwise. Where two or more wires are run in the same groove or chase, each crank after

the first (when those with single flies are used) must be fixed slightly above or in advance of the other, so as to prevent their fouling, and the wires must be spaced not less than about $\frac{1}{2}$ in. apart.

Carriages (fig. 638) of some sort are required to connect the wire or pull

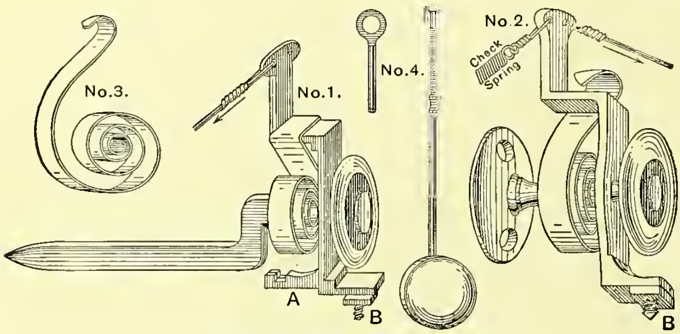


Fig. 638.—Bell Carriages and Fittings

No. 1, Driving; No. 2, With plate; No. 3, Spring; No. 4, Pendulum.

with the bell itself. They can be obtained either attached to an iron spike for driving (No. 1), or to an iron or brass plate for screwing to the bell board (No. 2). Before fixing the driving carriage (No. 1), the rose must be unscrewed and the lever and spring coil withdrawn, and these must be replaced after the iron spike has been driven the required distance into the wall or other support. Care must be taken in replacing the spring that it is slipped on to the proper square formed to receive it on the projecting end of the spike, so that when the lever is fixed in a vertical or nearly vertical position it will exert a certain amount of tension on the free end of the spring, which is hooked on to the horizontal arm of the lever, as shown in Nos. 1 and 2, fig. 638, and figs. 639 and 641. In course of time, when the strength of the spring becomes weaker, it can be shifted round on to the next square. The fixing plate of No. 2 can usually be screwed to the bell board without removing the fittings.

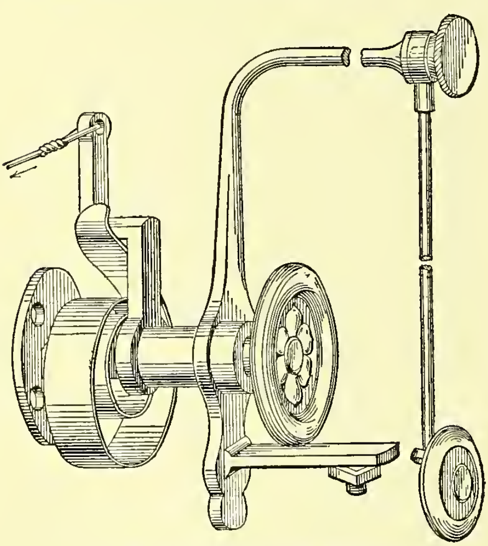


Fig. 639.—Bell Carriage with Pendulum

The action of the pull, being in the direction of the arrows, presses the horizontal arm against the free end of the spring coil, and causes the bell spring and bell to move slightly, and when released the vibration causes the bell to ring, or if the lever is smartly pulled the bell will ring, receiving fresh impetus when the pull is released.

Some carriages are provided with a short arm or "bit" (A, No. 1, fig. 638), from which **a pendulum** can be suspended behind the bell. Pendulums with eyes or springs (No. 4) are hung on in a somewhat similar manner to that of an ordinary clock, or a special arm may be provided, as shown in fig. 639, where the pendulum is hung high and in front of the bell. The latter form, however, is seldom used.

Bell springs (fig. 640) of steel are used for connecting the bells to the lever arms of the carriages. They are ordinarily of the single-coil pattern (No. 1), but larger and stronger springs with a double coil (No. 2) are also used. Springs vary from 4 to 6 in. in diameter. One end of the spring is secured to the lever arm by the nut B (Nos. 1 and 2, fig. 638), the other end being either copper-riveted

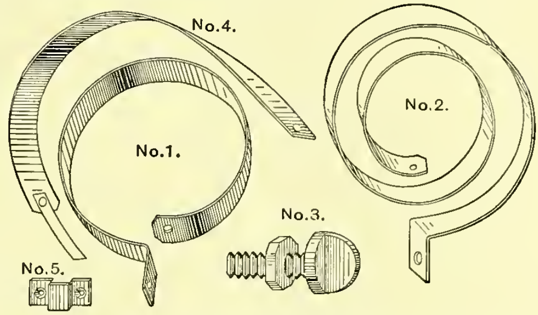


Fig. 640.—Bell Springs

No. 1, Single coil; No. 2, Double coil; No. 3, Bolt and nut; No. 4, Shutter spring; No. 5, Staple.

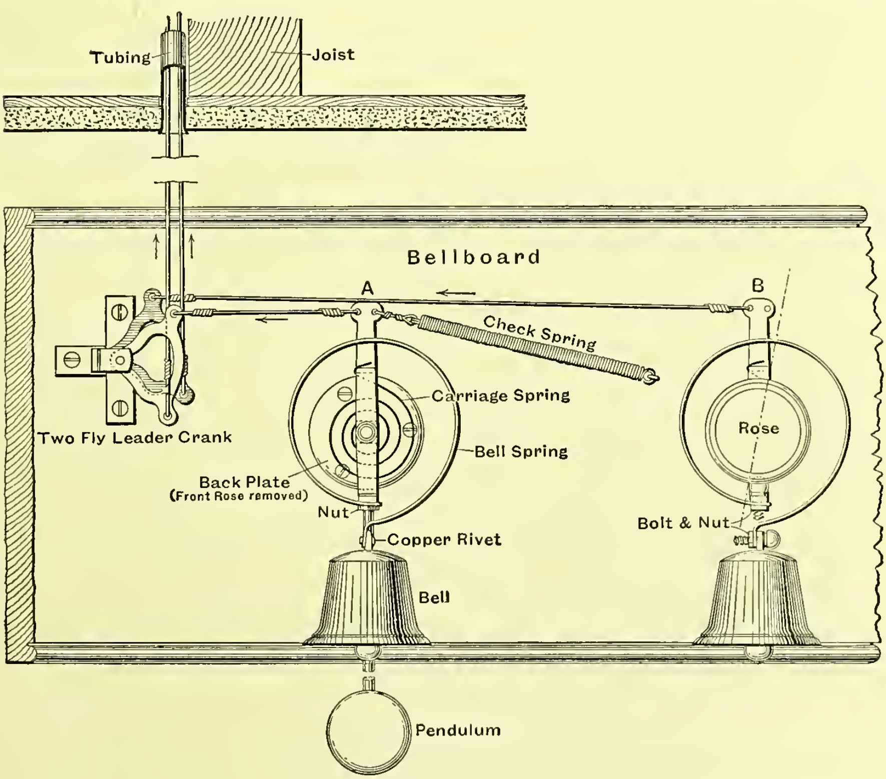


Fig. 641.—Bell Board with Two Bells

to the bell (A, fig. 641), or bolted to it by the separate bolt and nut (No. 3, fig. 640, and B, fig. 641). A similar bolt and nut is sometimes used to connect the spring to the lever arm (B, fig. 641) instead of to the fixed threaded bolts at B, fig. 638.

A *shutter spring* (No. 4, fig. 640) is occasionally used as an alarm, when fitted up with a bell attached to one end. When the shutters are closed at night the free end of the spring is slipped into the staple (No. 5) which has been screwed to one of the shutter flaps. Any attempt during the night to open the shutters will set the bell in motion. This spring can also be attached to a door, &c., any movement of which would set the bell ringing and thus give the alarm.

Check springs of steel or coppered steel wire, from 4 to 8 in. in length, are fixed between the top of the carriage lever and the bell board to counteract the pull of the wire on the other side of the lever, as shown in No. 2, fig. 638, and in fig. 641.

Bells and Fittings.—Fig 641 shows two bells fitted up on a bell board with all fittings, &c. The wires are brought down through the ceiling in a tube and attached to the two-fly leader crank, the respective arms of which should nearly coincide with each other to enable the wires to enter the tubing together without rubbing on the sharp edges of the mouth. It is advisable to open out the mouth of the tube or round off the sharp inner edges, and to let it project slightly beyond the face of the plaster as shown. The other arms of the flies are connected by wires to the upper ends of the lever arms of the respective carriages, and when required check springs are attached to the opposite sides, as shown at A, and secured to the bell board at the other end. The rose has been unscrewed from the bell carriage A to show more distinctly the lever, carriage spring, and back plate for screwing to the bell board.

When check springs are not used, some bellhangers fix the carriages with the arm leaning slightly out of the vertical on the opposite side from the pull, as shown by the dotted line at B. The carriage at A is kept more or less vertical by the wire pull and check spring balancing each other. The carriage at B is also shown in a vertical position, but it can be imagined that a pull is being exerted on it through its fly crank, which has been rotated slightly from behind the front fly to show it more distinctly.

CHAPTER II

PNEUMATIC BELLS AND SPEAKING TUBES

Pneumatic bells are very simple and convenient, and are sometimes considered preferable to electric or mechanical bells. Compressed air is the motive power, and as the pipes or tubes are fixed more or less out of sight, they are not so liable to injury, and, moreover, are not affected by moisture, which in many cases is found to be so detrimental to electric wires. Hence their suitability for use on board ship.

A pneumatic bell installation consists of an air-tight metallic tube of small diameter, having an indiarubber bulb at one end, which, on being pressed by hand direct or by means of a press button or bell pull, actuates a small bellows, which moves the mechanism of the bell and indicator.

The tube may be $\frac{1}{32}$ in., $\frac{1}{16}$ in., or $\frac{1}{8}$ in. in diameter, and being usually formed of composition material can be readily accommodated to any position.

The bells may either be of the single-stroke pattern or of the chattering variety, and continue to ring so long as pressure is applied to the bulb; and the indicator shows from which room or office the call has come. The indicators are similar in outward appearance to those used in electric work.

A combined pneumatic bell and speaking tube can be obtained by means of the fittings shown in fig. 642. One of these is fixed at each end of an air-tight tube $\frac{1}{2}$ or $\frac{3}{4}$ in. in diameter. The mouthpiece is of indiarubber, and contains a ball of celluloid or other material, which closes the opening when the mouthpiece is hanging downwards. The connection above the flexible tube has a vertical branch in which a small brass piston slides up and down, and a bell is fixed above the piston. When the bulb of the mouthpiece is squeezed, the air in the tube is compressed and forces the piston at each terminal against the bell above it. The mouthpiece can then be raised to the ear, when the ball inside falls away from the opening into the bulb, and conversation can be carried on in the usual way. Where two or more terminals are fixed in one room, the bells may be of different tones, or a code of signals may be arranged,—say, one ring for one room, two for another room, and so on.

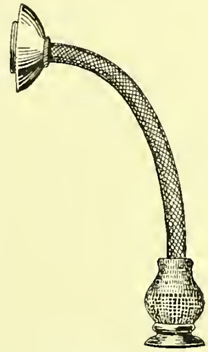


Fig. 642.—Black's Pneumatic Bell and Speaking Tube

Speaking tubes are used to enable verbal communication to be maintained between various rooms or floors of a house, office, or other establishment at moderate distances between extreme points, and where a telephonic installation may not be considered necessary or desirable. They are simple, economical, easily fitted up, and involve very little expense for upkeep. The various fittings required for the simplest installation are: (1) A tube of some description fitted up between the rooms which it is desired to place in communication with each other, and (2) mouthpieces with whistles attached, fixed at the ends of the tube.

The mouthpieces may be fixed against a wall at some convenient point so as to be available for general use, or the tubing can be carried to a table or desk, with the mouthpiece at the end. In the latter case the tubing may be brought either up from the floor or down from the ceiling, or a piece of flexible tubing may be attached to the fixed tube at the wall, so that, when not in use, the mouthpiece and flexible tube, termed a *terminal set*, can be hung up in the holder or hook out of the way.

When the tubing has to be brought from an adjoining wall to a table or desk some distance away, it can be done by taking up one of the floor boards and notching the joists, or, when this may not be practicable or desirable, by passing it along between the joists, or securing it to the side

of one of them, until it can be brought up or down vertically to the desired position. Where the distance is short and the service temporary, the tubing may be laid direct on the floor, and be protected by a grooved fillet or batten, the exposed edges of which should be chamfered or rounded, so as to offer only a slight obstruction where there may be any traffic.

The tubes should be fitted up in such a way as to have smooth inner surfaces and air-tight joints, sharp bends being avoided as far as possible. They are supplied in $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., or 1 in. diameters, the sizes in most general use being those of $\frac{3}{4}$ in. and $\frac{7}{8}$ in. diameter.

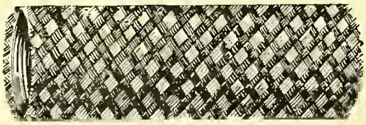


Fig. 643.—Braided Flexible Tubing

Various materials are used for the tubing. For short distances zinc and composition or gas tubing is usually employed when to be fixed against walls and under floors or ceilings, &c. Copper tubing is occasionally used in important exposed positions. When the distance is great, welded steel conduit, as supplied for electric lighting, is recommended. These are fixed in the usual way by means of pipe hooks or clips.

Ordinary vulcanized **indiarubber tubing** is sometimes used for temporary purposes, but for more permanent use and as terminal sets what is termed **flexible tubing** (fig. 643) is generally employed. This tubing may either be plain, red, black, blue, green, maroon, &c., or it may be covered with similarly coloured worsted, mohair, or silk braiding for ornament and protection. The silk-covered tubing is very expensive, but it is much superior in appearance and wears better. The flexible tubing is lined with a tinned-wire spiral coil, which prevents kinking, and does not rust or affect its durability.

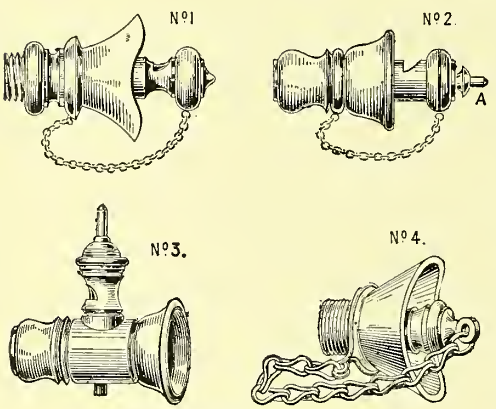


Fig. 644.—Mouthpieces and Whistles

No. 1, Oval with male screw; No. 2, Round with female screw and indicator (A); No. 3, Improved whistle; No. 4, Oval brass.

Zinc tubing is supplied in 8-ft. lengths, with socket or ferrule joints, the various lengths being soldered together. In very common work the slightly tapered ends of the tubes are merely slipped into the corresponding tapered ferrules, forming a sort of slip joint. Bends of fairly large radius should be used where possible in preference to sharp right-angle elbows.

Compo tubing, being obtainable in long lengths, and being easily bent for any required change of direction, is suitable for many positions, and is often employed. Care must be taken in fixing it to see that it is properly protected from injury, and that the staples or holdfasts for securing it to the walls, &c., are not driven too tightly against it. Being softer than zinc, it is more liable to injury.

Mouthpieces (fig. 644) may be either round or oval in shape, and fitted with plugs or whistles, and also with indicator pins when there are a number of them in a row. When a plug is provided at one end instead of a whistle, the call can be made from that end only. When not in use the whistles would be inserted in the mouthpieces, and the pins, when such are provided, pressed home. When the occupant of one room wishes to get into communication with the other room, he would withdraw the whistle or plug and blow gently through the tube, causing the whistle at

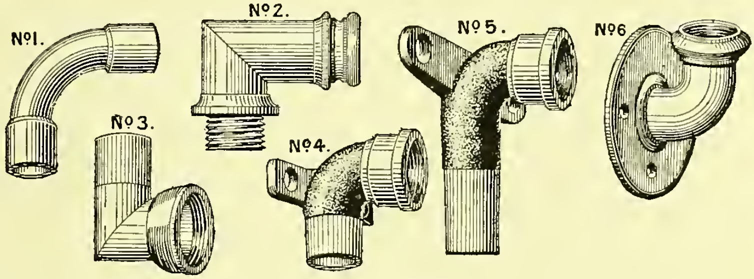


Fig. 645.—Elbows

the other end to act, and at the same time forcing the indicator pin outwards, when one is used. When several mouthpieces are fitted up in a row, it would be difficult to tell which whistle blew unless some such arrangement as the indicator pin were adopted. No. 3 shows Comyn Ching & Co.'s improved form of mouthpiece and whistle complete in one, the whistle being always in place for use. The mouthpieces are usually made of cocus wood or ebonite, and, for superior work, of brass or ivory. They can be had with male or female screwed ends to suit the mounts for connecting them to the metallic or flexible tubing.

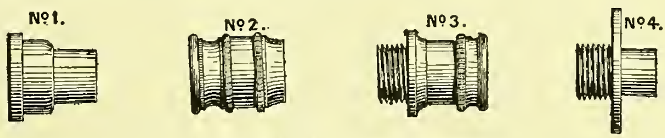


Fig. 646.—Brass Mounts or Connections

No. 1, Socket or ferrule; No. 2, Female coupler; No. 3, Male pommel; No. 4, Pommel with plate.

To prevent risk of loss, the whistles should be secured to the mouthpieces by brass chains, fixed either by screws or, at a slight extra cost, by brass bands (No. 4).

Elbows, &c.—When the tubing is fixed against a wall or partition its connection to the mouthpiece is made by means of a special elbow having a male or female screw cut on or in it suitable for the mouthpiece. If the tube passes through the wall, a wall plate with male or female screw is used. Fig. 645 shows various forms of elbows, No. 1 being for changing the direction of the zinc tubing, No. 2 for connecting iron to flexible tubing, and Nos. 3 to 5 for connecting mouthpieces to metallic tubing. Nos. 4 and 5 are fitted with straps, ears, or back plates for securing them to the walls or to woodwork, &c., and, being of brass, are tinned at the

ends for soldering to the tubing. No. 6 shows a wall plate elbow for attaching a male mouthpiece, where the tubing comes through and is carried up the face of the wall.

Mounts or connections (fig. 646) of brass are required for joining iron, metallic, or braided tubing to each other, or to the mouthpieces to be connected to them. The ends to be soldered are plain and tinned, the other ends being screwed, male or female as required, with the ordinary standard thread, except those for taking the braided tubing, which has a finer female thread cut in the socket.

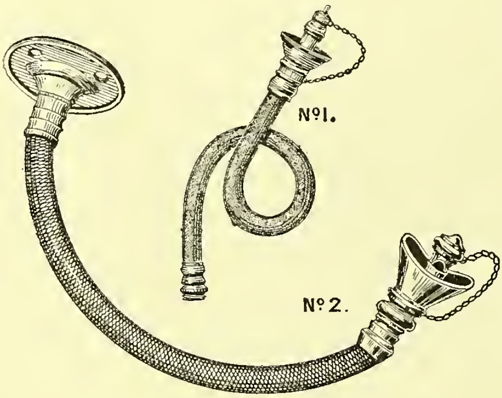


Fig. 647.—Terminal Sets

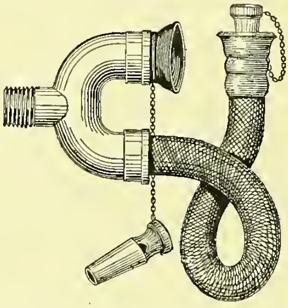


Fig. 648.—"Pontifex" Patent Terminal Set

Flexible terminal sets (fig. 647) comprise in each case a mouthpiece and whistle, and a short length of flexible tubing with brass mounts and unions for connecting it to the mouthpiece and metallic tubing. No. 2 is fitted with a wall plate for connecting to a tube coming through the wall.

The "Pontifex" terminal set (fig. 648) is an improvement on the ordinary fitting. It consists of a junction piece screwed for connection to iron tube, and having two openings, one to be used as a mouthpiece, and the other (with a piece of flexible tubing attached) as an earpiece. If necessary, flexible tubing of any required length can be attached to the mouthpiece and the earpiece.

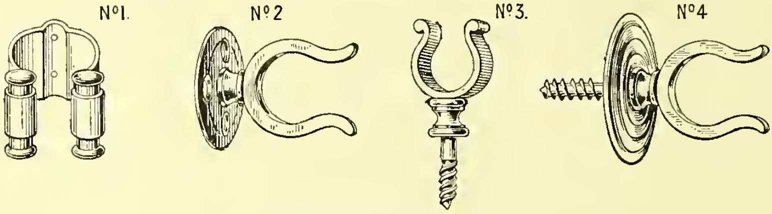


Fig 649.—Mouthpiece-holders

Holders (fig. 649) of various descriptions are provided for supporting the tubing or terminal sets when not in use, and are generally made of brass. No. 1 shows a spring holder with bone ends, similar to a billiard-cue holder. Nos. 2, 3, and 4 show fork pattern holders, with cast plate holed for screws (No. 2), with wood screw (No. 3), or with wood screw and

stamped rose (No. 4) for attaching to walls, &c. If it is impracticable to screw them to any adjacent woodwork, a neat deal or hardwood rail should be provided to receive them for fixing against a plastered wall.

Fig. 650.—Professional Door Plate

Professional door plates (fig. 650) are supplied fitted up and lettered as shown, or as required, of brass, with brass bell pull or push and mouthpiece. Corresponding plates are also to be obtained, having much larger and projecting openings as mouthpieces.

Multiple mouthpiece cases (fig. 651), of mahogany, oak, or walnut, fitted with ivory numbered tablets, and prepared to take two or more mouthpieces, are also obtainable. They are arranged for fixing against a wall, to which they are secured by screws or brass-headed nails to plugs driven into the walls.

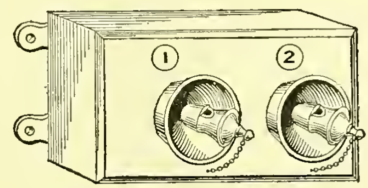


Fig. 651.—Multiple Mouthpiece Case

It is frequently necessary for a number of flexible tubes, with their mouthpieces communicating with various other rooms or offices, to be fitted up at one end of a table or desk convenient for use by the occupant. In this case they should be neatly supported on a grooved rest or other support, and numbered, lettered, labelled, or otherwise distinguished by differently coloured braiding, to indicate the rooms, &c., with which they are in communication.

Section X

ELECTRIC BELLS AND TELEPHONES

BY

F. G. BELL, A.M.I.E.E.

Section X

ELECTRIC BELLS AND TELEPHONES

CHAPTER I

ELECTRIC CELLS, BATTERIES, AND WIRE

Electric bells as a means of signalling offer great advantages over crank or pneumatic bells. They are easier to install, and, when properly understood, can be more readily adapted to the requirements of users.

In order that the action of an electric bell may be better understood, it is advisable to examine some of the accessories with which it is used. Such accessories may broadly be included under the three headings: (*a*) Batteries, (*b*) circuit-closing devices, and (*c*) wire.

An electric battery is a group of cells, each of which consists essentially of two plates of dissimilar metals, or their equivalents, partly immersed in an acidulated solution. The very simplest form consists of a glass or stoneware jar containing a solution of dilute sulphuric acid, in which a zinc and a copper plate are partly immersed, but not touching each other. The zinc and copper plates are called the *elements*, the acidulated solution is the *electrolyte*, and the jar may be called the *containing vessel.* The complete combination is described as a battery *cell.* In such a cell no action takes place so long as the zinc and copper plates remain out of contact with each other. Fig. 652 illustrates this type of cell, C being the copper and Z the zinc plate. If one end of a piece of wire is connected to Z, and the other end to C, as shown by the dotted line, an electric current is set up which circulates from the Z to the C plate *inside* the cell, and from C through the connecting wire to Z *outside* the cell, thus completing what is called *the electric circuit.* Although, under the circumstances above set out, there is no visible evidence that a current is passing, it is quite possible to obtain such evidence by the use of suitable apparatus, of which, however, it is at

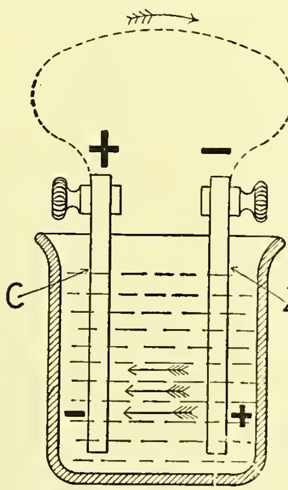


Fig. 652.—Cell with Copper and Zinc Plates

present too early to speak. It is necessary to emphasize the importance of the electrical circuit referred to. In working out systems in which certain apparatus has to be actuated electrically, such apparatus must be arranged so that when operated it is included in the electrical circuit—that is, between the copper and zinc plates, or their equivalents, outside the cell.

In order to simplify reference to the elements, the zinc plate is called the *positive* and the copper plate the *negative* element. The points to which the wire is connected outside the cell are called the *poles*, the copper connection being the *positive* or + pole, and the zinc connection the *negative* or − pole. It should be noted that the naming of the poles is the opposite to the naming of the elements, but if it is remembered that the direction of the current inside the cell is from zinc to copper, and outside the cell from copper to zinc, identification will be simple. In future reference the signs + and − will be understood to refer to the poles of the battery.

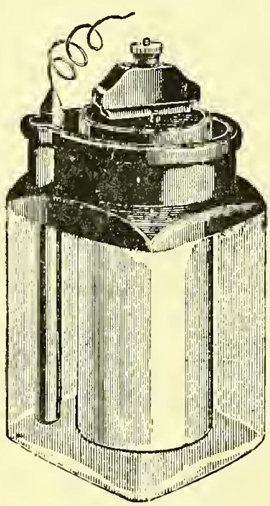


Fig. 653.—The Leclanché Porous-pot Cell

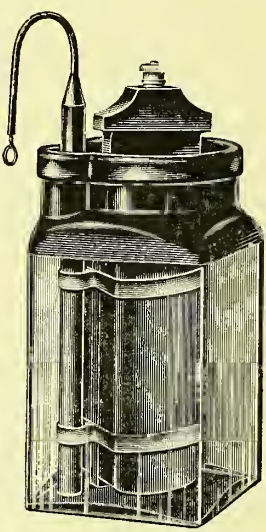


Fig. 654.—The Leclanché Agglomerate 2-block Cell

The type of cell above described has been selected in order that the details of the electric circuit may be clearly grasped, but, whilst very useful for demonstration purposes, such a cell could not be used in actual practice owing to local chemical action on the zinc. It illustrates, however, in a simple manner the main features which exist in a modified form in all battery cells.

The type of cell used commercially for operating electric bells and the like is **the Leclanché type**, of which many modifications are made. The principal of these are:

(*a*) The Leclanché porous-pot cell.
(*b*) The Leclanché agglomerate 2-block cell.
(*c*) The Leclanché agglomerate 6-block cell.
(*d*) The Leclanché dry cell

The Leclanché porous-pot cell (fig. 653) comprises a glass cell containing a saturated solution of sal-ammoniac, a zinc rod (the positive element), and a porous pot, the latter containing a plate of carbon surrounded by a mixture of crushed carbon and peroxide of manganese (the negative element). The carbon plate is provided at its extremity with a brass screw, under which the necessary wire connection is fixed when in use. The zinc rod has a copper wire attached to it, to which the necessary connection is made.

The Leclanché agglomerate 2-block cell (fig. 654) comprises practically the same parts as the porous-pot cell, except that the porous pot is dispensed with, and the carbon and peroxide of manganese mixture is made up in the form of two solid blocks, which are held one on each side of the carbon plate by two indiarubber rings. These rings have small loops in them into which the zinc rod is fixed.

The Leclanché agglomerate 6-block cell (fig. 655) is a type which is intended to be used under circumstances requiring a cell capable of doing much heavier work than either of the preceding. It comprises a stoneware jar containing a solution of sal-ammoniac. The positive element is a large cylinder of zinc. The negative element comprises a carbon rod having six grooves running from end to end. In each of these grooves a circular block of carbon and peroxide of manganese mixture is placed. They are held in position by a canvas wrapping and indiarubber rings. Owing to the large surface exposed for action between the elements, such a cell is capable of an output of current many times greater than the porous pot or the 2-block agglomerate type of cell. In most ordinary cases the latter types are sufficient, but in special cases, examples of which will be mentioned later, the 6-block cell should be used.

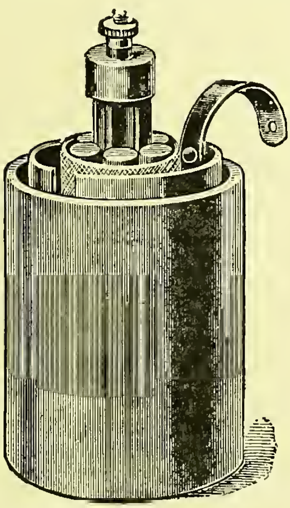


Fig. 655.—The Leclanché Agglomerate 6-block Cell

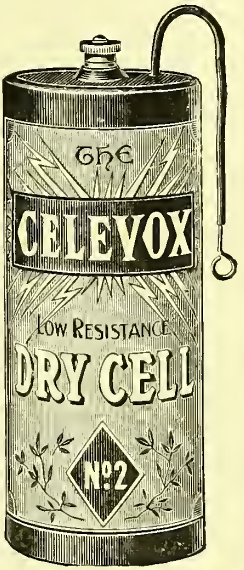


Fig. 656.—Dry Cell

The dry cell (fig. 656) comprises the same elements as the other types, but instead of a sal-ammoniac solution the electrolyte consists of an acidulated pasty substance. The containing vessel is of zinc, which also forms the positive element. The dry cell is capable of a larger output of current than the Leclanché porous pot or agglomerate two-block cell, but possesses the disadvantage of incapacity for renewal of parts. When a dry cell is exhausted it is best to consign it at once to the scrap heap, whilst the wet types can have any of their parts renewed, and will last many years. The dry cell, however, is very convenient, as it can be got to work quickly, and saves considerable time when repairs are being effected in which it is necessary to renew the battery. Most manufacturers identify their dry cells by some fancy trade name, as in fig. 656, which illustrates the "Celevox" type.

It is a great mistake to use too little battery power on an installation. The battery is the essence and heart of the whole system, and there should always be a large margin of safety between the battery actually used and that which would be just sufficient for the purpose.

Current and Pressure.—A single cell is capable of doing a certain amount of work, the actual amount depending on the quantity of current and the pressure or force with which it is given off. The unit of current is the *ampere,* and the unit of pressure is the *volt.* The pressure of a cell of any given type remains the same, irrespective of the size of the elements. The quantity of current, however, varies, first, according to the size of the elements, and, secondly, according to the distance at which they are placed from each other. Variations in this latter respect affect the condition of the cell by increasing its resistance. By resistance is meant "the opposition offered to the passage of the current". The unit of resistance is the *ohm.* By the formula known as *Ohm's Law* the amount of current which a cell is capable of discharging can be found by dividing the pressure or electromotive force (E.M.F.) by the resistance (R). The result gives the current (C) in ampères, which can be obtained at the terminals of the cell. Thus, if the E.M.F. is 2 volts, and the resistance 4 ohms, the amount of current across the terminals is $\frac{2}{4} = \cdot 5$ ampere.

If, however, the external circuit—that is, that portion of the circuit outside the battery—is appreciable, this also must be taken into consideration. In this case the formula according to Ohm's Law is as follows:—Divide the E.M.F. by the sum of the internal resistance (R) and the external resistance (r), thus: $C = \frac{\text{E.M.F.}}{R + r}$.

If, therefore, the E.M.F. and R remain as before and r is 4 ohms—

$$C = \frac{2}{4 + 4} = \frac{2}{8} = \cdot 25 \text{ ampere.}$$

The quantity of current is therefore exactly half the quantity obtained with no external resistance in the circuit, the total resistance being doubled.

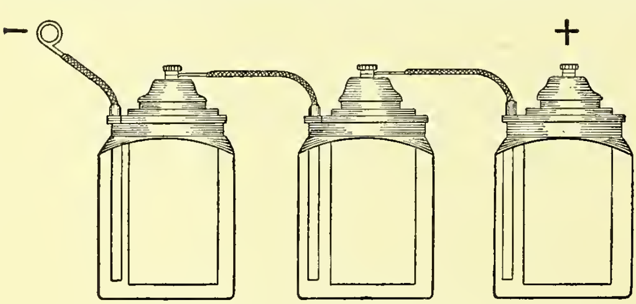


Fig. 657.—Three Cells connected in Series

Connected Cells.—Since the current obtainable from a single cell is not sufficient to be of much practical use, a number of cells are connected together in various ways. These may be described as (*a*) Series, (*b*) Parallel, and (*c*) Parallel-series. The connected cells are known as a *battery.*

To connect cells in series the negative pole of one cell is connected to the positive pole of the next cell, until the desired number are connected in the series. Fig. 657 shows three cells so connected. The free zinc at one end and the free carbon at the other end are the negative and positive poles respectively, to which the connections must be made. The electromotive force of a series-connected battery is equal to that of one cell multi-

plied by the total number of cells in the series, but the quantity of current at the terminals is only equal to that of one cell. Using Ohm's Law to demonstrate this, and adhering to the same units as previously, we have in the case of two cells—

$$C = \frac{\text{E.M.F.} \times 2}{\text{R} \times 2} = \frac{2 \times 2}{4 \times 2} = \cdot 5 \text{ ampere.}$$

It will be seen that a series connection not only increases the E.M.F., but also increases the internal resistance in direct proportion to the number of cells. If, however, there is an external circuit of 4 ohms, as in the previous calculation, the quantity of current does not bear the same proportion to that obtained with a single cell. Thus—

$$C = \frac{\text{E.M.F.}}{\text{R}r} = \frac{2 \times 2}{(4 \times 2) + 4} = \frac{4}{12} = \cdot 33 \text{ ampere.}$$

It will thus be seen that with an external circuit of a given resistance the quantity of current in the circuit can be increased by increasing the E.M.F.

By connecting **cells in parallel** a different effect is obtained, the E.M.F. remaining the same as that of a single cell, but the current being equal to that of one cell multiplied by the total number. This method consists in connecting all the positive poles and all the negative poles together, as shown in Fig. 658. The total internal resistance is equal to that of one cell divided by the total number. Working out the formula for current, using two cells connected in parallel, we obtain—

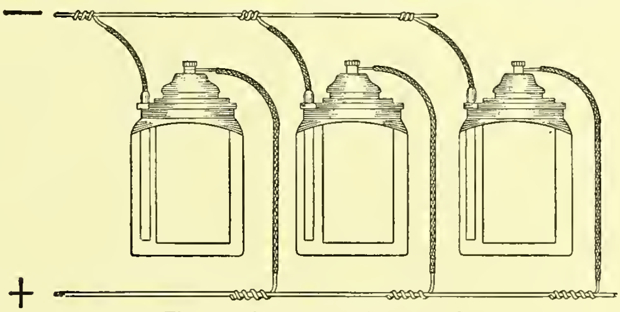


Fig. 658.—Cells connected in Parallel

$$C = \frac{\text{E.M.F.}}{\text{R} \div 2} = \frac{2}{4 \div 2} = \frac{2}{2} = 1 \text{ ampere.}$$

The quantity of current in this case is exactly double that obtained from a single cell.

The parallel-series connecting of batteries is illustrated in fig. 659, from which it will be seen that in the case illustrated two sets of three cells are connected in series, the end carbons being joined together to form the positive and the end zincs joined to form the negative pole. Six cells connected as in fig. 659 would have an E.M.F. equal to that of three cells connected in series, and an output of current equal to that of two cells connected in parallel, thus—

$$C = \frac{\text{E.M.F.}}{\text{R.}} = \frac{2 \times 3}{4 \times 3 \div 2} = \frac{6}{6} = 1 \text{ ampere.}$$

This, it will be seen, is exactly the quantity of current obtained by the same formula when two cells in parallel were used.

In electric-bell work the series connection is in most cases sufficient, but sometimes the external circuit is of very low resistance and heavily worked, in which case an advantage is gained by a series-parallel connection. Suppose that a system is working with three cells, and that it is found that the batteries quickly become exhausted, the addition of three more cells in parallel will double the life of the battery.

Circuit-closing devices are dealt with later under the heads of electric-bell pushes, burglar alarms, and fire alarms.

Wire is a most important accessory to electric signalling apparatus. It must be of copper and requires to be insulated—that is, covered with a non-conducting material. Such material is found in indiarubber, gutta-percha, cotton, silk, paraffin wax, &c. The conductor is drawn in different

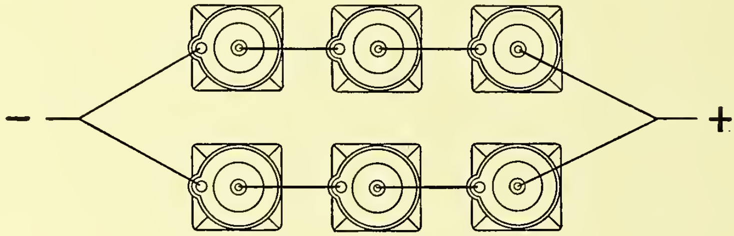


Fig. 659.—Six Cells connected in Parallel-series

thicknesses to a standard gauge known as the imperial standard wire gauge (S.W.G.). For ordinary electric-bell work inside a house, and in situations free from damp, the wire should be made to the following standard specification:—The conductor to be No. 20 S.W.G. high-conductivity copper wire, tinned, covered with pure indiarubber and two layers of cotton, and then soaked in paraffin wax. In some cases the wire is of No. 22 S.W.G., but it is much better practice to use nothing less than a No. 20, as, in addition to the increased conductivity, its mechanical strength is considerably greater. Some fitters endeavour to effect an economy by using wire from which the indiarubber coating has been omitted, but it is a false economy, and should never be practised by a fitter who values his reputation.

For damp situations and for running outside a building, the wire should be made to the following specification:—The conductors to be No. 20 S.W.G. tinned copper, covered with pure and then with vulcanized indiarubber, lapped with prepared tape, then braided and served with an insulating compound.

Underground wires should be insulated as in the last specification, and then covered with lead, and should be run in iron barrel, in which inspection boxes should be fitted at convenient points.

An alternative wire for the above is equally effective and somewhat more economical. The specification is as follows:—Conductors to be No. 20 S.W.G., high-conductivity copper, insulated with impregnated paper, and lead covered.

CHAPTER II

MAGNETS

The magnet plays such an important part in electric bells and accessory apparatus that a brief glance at the phenomena of magnetism will probably assist the reader materially to understand the working of the various pieces of apparatus to be described in the following pages. There are two kinds of magnets—namely, permanent magnets and electro-magnets.

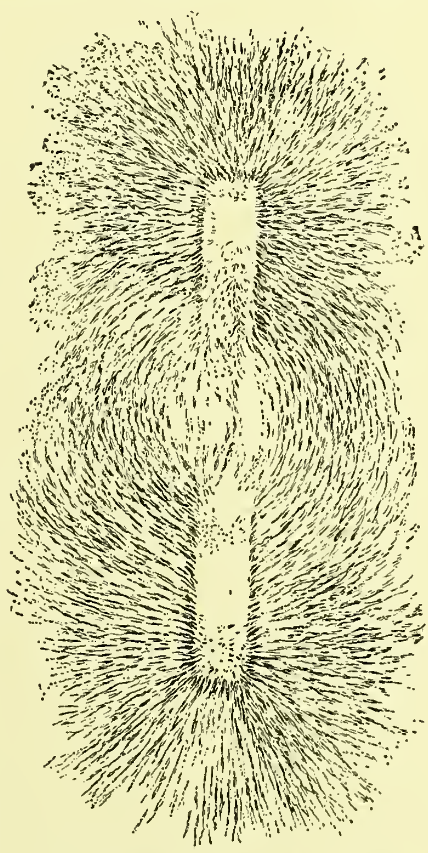


Fig. 660.—Lines of Force in Magnetic Field

The permanent magnet is familiar to most people. In its simplest form it consists of a bar of steel which has been magnetized by one of the various methods available. Such a magnet will attract to itself small particles of iron or steel, and retain them until forcibly separated. If it is suspended so that it can move freely on an axis, it will always point in a certain direction, viz. nearly north and south. Thus we have the terms north pole and south pole applied to those ends of the magnet which, under these conditions, point north and south respectively. Further, the like poles of two magnets will repel, whilst the unlike poles will attract each other. If a magnet is supported so that it is free to move on an axis, and is approached by a second magnet presenting its north pole to the south pole of the suspended magnet, the latter, owing to mutual influence between them, will be attracted to the former; but if the north pole of the one is presented to the north pole of the other, the repelling property of the magnets will cause the one which is suspended to move away from the one approaching, and it will be practically impossible to bring them into contact with each other.

The space immediately surrounding the poles of the magnet is permeated by magnetic lines termed **lines of force**, and the space thus permeated is known as the magnetic field. Whilst these lines of force are, of course, invisible, evidence of their existence can be obtained in the following simple manner. Place a bar magnet on the table, and place a sheet of white paper over it. Now take some iron filings and sift them on the

paper. They will arrange themselves in symmetrical curves and lines representing the lines of force (fig. 660). It will be observed that the

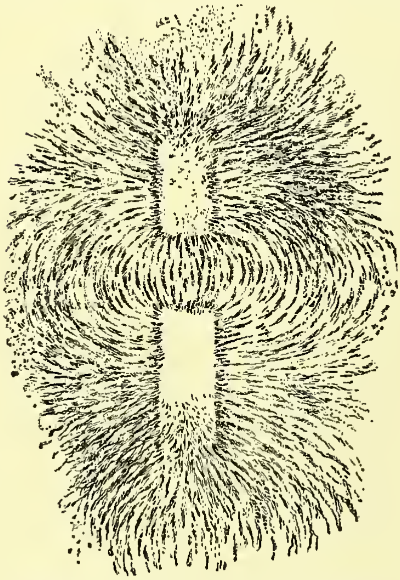


Fig. 661.—Lines of Force between the North and South Poles of Two Magnets

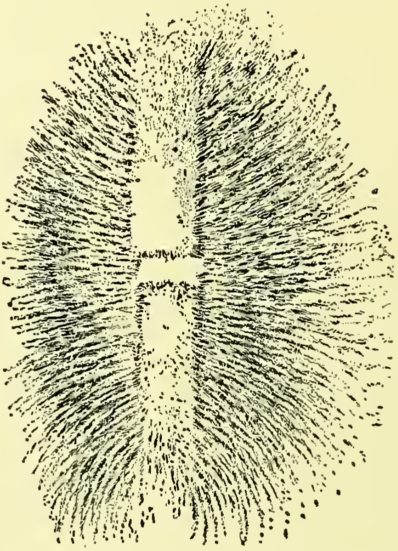


Fig. 662.—Lines of Force between Two Similar Poles of Two Magnets

lines are much more numerous at the ends or poles than they are towards the centre of the magnet, and that the actual centre is practically devoid of them.

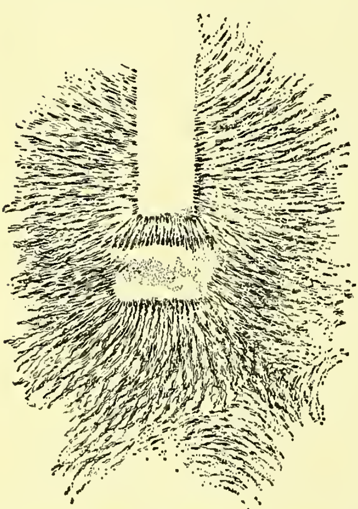


Fig. 663.—Lines of Force with a Piece of Iron in the Magnetic Field

By this method it is a simple matter to observe the effect which similar and dissimilar poles of a magnet have upon each other. Fig. 661 shows the effect of a north and a south pole placed opposite each other beneath the paper. It will be seen that the lines of force pass straight across the space between the poles, and that the curves bend round till they meet, showing the attraction of two dissimilar poles for each other. Fig. 662 shows the effect of two similar poles (two north or two south) placed opposite each other. It will be seen that the space between the poles is practically clear of the lines of force, and that the curves bend away from each other, the result of the mutual repulsion exercised by similar poles. Fig. 663 shows the effect of introducing a piece of ordinary iron into the magnetic field. The lines of force are attracted from their normal position towards the iron. It will also be observed that lines of force

radiate from the piece of iron thus demonstrating that a piece of iron placed in the magnetic field becomes for the time being virtually a magnet. In order to produce a more powerful magnetic field, the magnet is frequently made of horse-shoe shape, thus bringing the north and south poles near to each other, and, by virtue of their attracting properties, increasing the number of lines of force between the poles. Fig. 664 illustrates a filing figure of such a magnet.

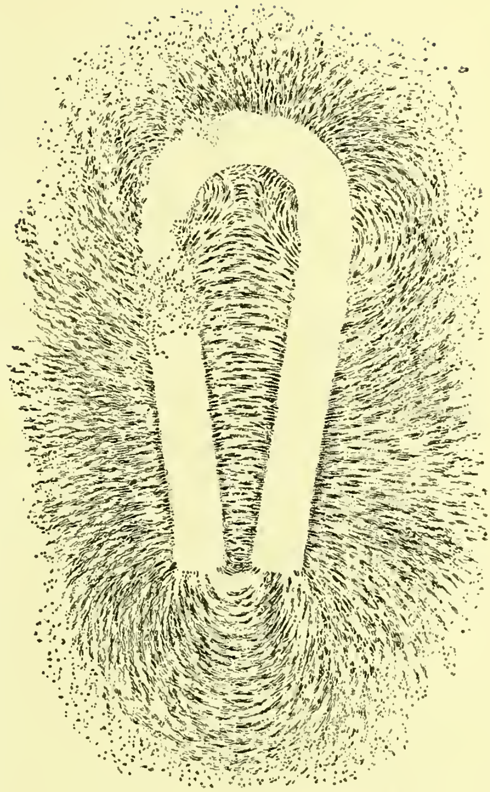


Fig. 664.—Lines of Force of a Horse-shoe Magnet

An electro-magnet, as distinguished from a permanent magnet, consists of a bar of soft iron, which normally exhibits no sign of magnetism, and around which several turns of insulated wire are wound. Fig. 665 illustrates such an arrangement at N S. If one end of the wire is connected to the + and the other end to the − pole of a battery as shown, a current passes through the wire, and the iron bar immediately becomes magnetized, and will in this condition exhibit all the features of a permanent magnet, one end being the north and the other end the south pole. In the illustration the electro-magnet is connected with the positive pole to the right-hand end and the negative to the left. The current passes in the direction of the arrows, and the result is to produce a north and a south pole at the positions so marked. If, however, the connection to the battery is reversed, the polarity of the electro-magnet will also be reversed. Thus the polarity of an electro-magnet depends on the direction in which the current is passing. Immediately the circuit is broken, the

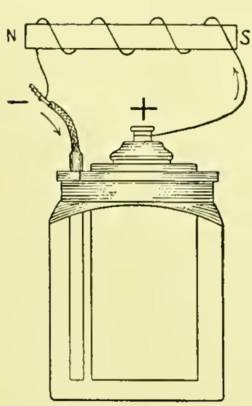


Fig. 665.—Electro-magnet

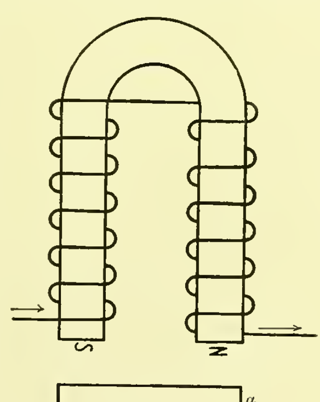


Fig. 666.—Horse-shoe Electro-magnet

iron bar regains its normal non-magnetic condition. If instead of soft iron we use hardened steel, the bar will, after a current has been passed around it as above, become permanently magnetized, and this method is frequently adopted to produce permanent magnets.

Electro-magnets of various forms have been devised with the object of increasing their power, but the horse-shoe type (fig. 666) is the most used. This consists in its simplest form of a bar of iron bent into a U shape, with the wire wound on each arm; when a current passes through the wire the arms of the U become polarized—one with north and the other with south polarity. If, while the current is passing, a bar of iron *a* is held in front of the poles, it will be strongly attracted and held by the electro-magnet, but will fall away immediately the circuit is broken. This piece of iron is called the *armature*, and a corresponding part will be found in all electro-magnetic apparatus used in ordinary practice.

CHAPTER III

THE ELECTRIC BELL AND BELL PUSHES

The Electric Bell is made up of the following essential parts:—

(A) Electro-magnet.
(B) Armature with hammer.
(C) Contact-breaker.
(D) Bell gong and pillar.
(E) Armature spring.
(F, G) Connecting terminals.

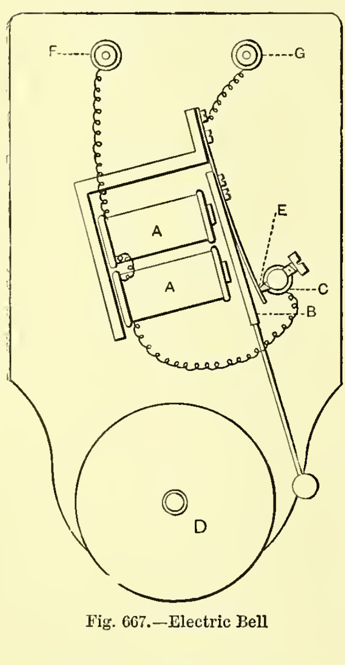


Fig. 667.—Electric Bell

These parts are indicated in fig. 667. which shows an electric bell with the cover removed. One end of the wire of the electro-magnet is connected to the terminal F, and the other end to the contact-breaker C. The iron frame of the movement is connected to the terminal G. The contact-breaker C is provided with an adjustable screw, the point of which rests normally in contact with the end of the armature spring E. If a battery is connected to the terminals F and G, the following circuit is established: from the battery to the terminal F, thence through the wire of the electro-magnet A to the contact-breaker C, and from the tip of the contact screw through the armature spring E and the iron frame, to the terminal G and the other side of the battery.

The electro-magnet A is immediately energized, and, exerting its attract-

ing influence on the armature B, causes it to be drawn rapidly forward. This movement causes the hammer knob to strike the bell gong D. At the same time the armature spring E breaks contact with the screw point of the contact-breaker C. Immediately this happens the electro magnet A becomes de-energized, losing its magnetism and allowing the armature to

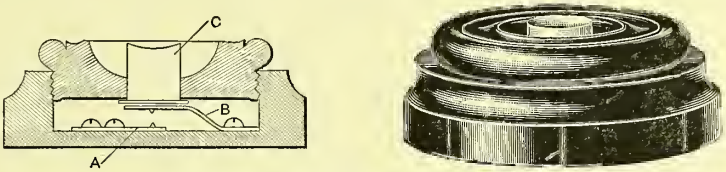


Fig. 668.—View and Section of Electric Bell Push

fall back, till the spring E again makes contact with the point of C, when it is again attracted; and the cycle of operations is thus repeated again and again as long as the circuit is kept closed.

The tip of the contact screw C, and the point of the armature spring E, at which it makes contact, are usually of platinum, as a very vivid sparking is set up, and nearly all other metals soon become oxidized to a sufficient extent to prevent good contact when the armature is in its normal position.

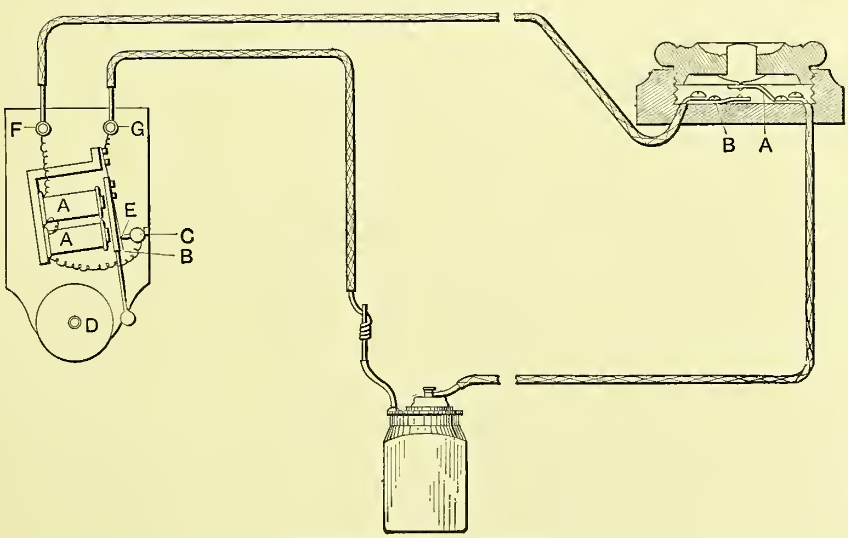


Fig. 669.—Simple Electric-Bell Circuit

The Electric Bell Push is the simplest and best-known device for operating an electric-bell circuit. It consists of two contact springs of German silver or other metal fitted in suitable mountings of metal, wood, porcelain, &c. Fig. 668 illustrates a good standard type of wood push; A and B are the two contact springs, and C is the push button. Pressure on the button C causes the spring B to make contact with A. In addition to the screws which fix the springs in position, there is to each spring a screw to which the wire connections are to be made (fig. 669). These

screws are generally larger than the fixing screws, or they are provided with a washer under which the wire can be clamped. The wires enter the push from the back through a hole made for that purpose.

The ends of the wire must be prepared for making the connection. This is done by stripping off the insulation for about $\frac{3}{4}$ in. from the end, either by scraping with a knife or unwinding the cotton; if the former, great care must be taken not to cut into the copper, otherwise when bent round the connecting screw it would be very liable to break. Having prepared the ends of the wire, the connecting screw should be partly drawn, and the wire bent round it under the head in a right-hand direction, that is, in the same direction as the screw will turn when being tightened up. This prevents the wire becoming squeezed from under the screw head when tightened.

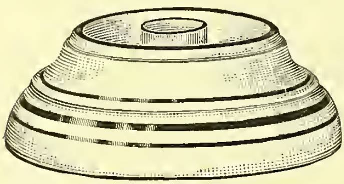


Fig. 670.—Porcelain Bell Push

Fig. 669 is a fully detailed diagram of **a simple electric-bell circuit**, showing the interior of the bell push in order that the circuit may be quite clear. The − pole of the battery is connected to the terminal G of the bell, and the + pole to one spring A of the push. A second wire connects the terminal F of the bell to the spring B of the push. Under normal conditions no action takes place, because the circuit is incomplete. The pressure on the push button brings the springs A and B together, and this completes the circuit and causes the bell to ring in the manner above described, the bell continuing to ring as long as the push is kept depressed.

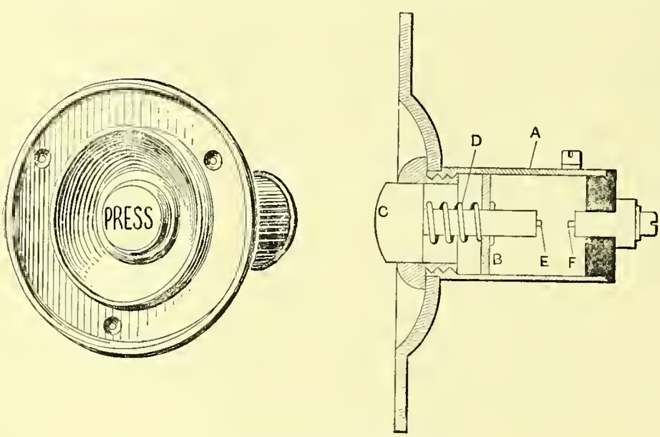


Fig. 671.—Brass Barrel Push

In fig. 669 the wires are represented with their insulated covering, and the bell, push, and battery are shown in detail. In future diagrams the bell and push will be represented in outline only, the wires by simple lines, and the battery in the usual diagrammatic method, thus |; this represents one cell, the short line being the − pole, and the long line the + pole.

Various types of electric bell pushes are made to suit the requirements of users, and the selection of suitable types must be governed by circumstances. They are made in wood, porcelain, brass and other metals. In private houses the designs of the pushes are generally required to harmonize with furniture and decorations. Fig. 670 illustrates a porcelain

push; the springs can be mounted on a wood or a porcelain disc, the front part screwing into the back in the same manner as in wood pushes. A porcelain back is unaffected by damp, and this alone should cause it to be used in preference to a wood back.

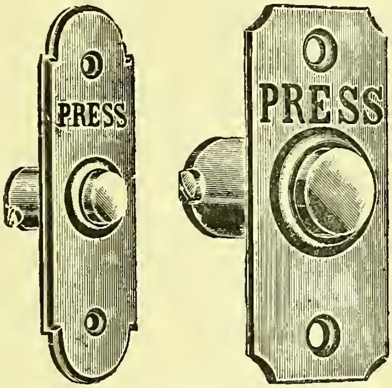


Fig. 672.—Barrel Pushes with Narrow Plates

For fixing at entrance doors and other positions which may be more or less exposed to weather, a brass water-tight push, such as fig. 671, must be used. This is known in the trade as a *barrel push.* The section shows the manner in which the parts are arranged; A is the barrel, in the centre of which there is a division B; the push-button C is held outwards by the spring D: when it is pushed inwards the point E makes contact with the point F, thus closing the circuit.

Sometimes a push of this type is fixed on a mahogany or walnut block. In the event of the push requiring to be fixed on narrow door posts, the types shown in fig. 672 are generally used. The only difference between these and fig. 671 is in the shape of the front plate.

For bedrooms a hanging push, sometimes known as a *pear push,* is generally fixed. Fig. 673 illustrates

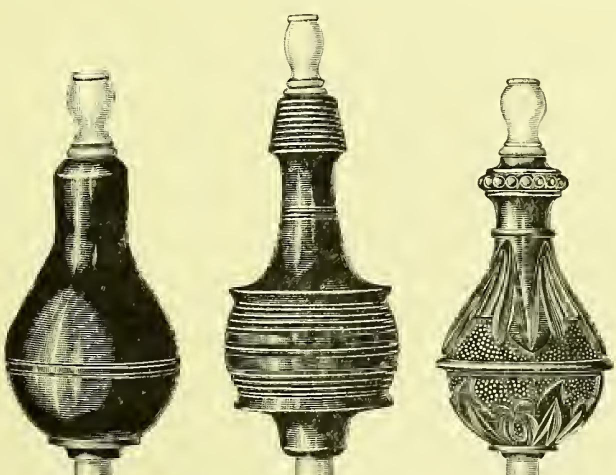


Fig. 673.—Pear Pushes

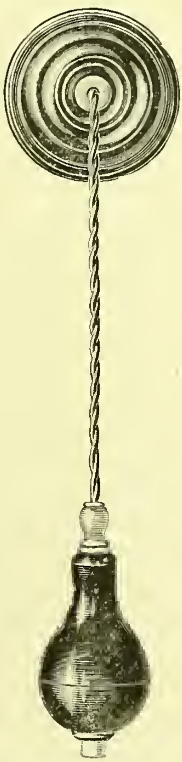


Fig. 674.—Pear Push and Wall Rosette

several designs. A length of flexible silk-covered double wire, in which the conductor consists of several strands of fine wire, is connected to the push springs at one end, the other end terminating on two brass terminal plates on a wall rosette (fig. 674). This rosette is fixed near the ceiling,

allowing the push to hang in the desired position, generally by the bedside. The circuit connections are made on the terminal plates of the rosette.

A very useful type of circuit-closing device, known as a *floor push*, is illustrated in fig. 675. This is practically a barrel push with a removable plunger. It is intended to be let into the floor under a dining-room table, and to be operated by the foot.

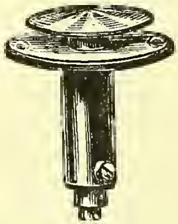


Fig. 675.—Floor Push

Other types of push with one or more buttons, such as fig. 676, are designed to stand on office desks or tables. In practice the push is fitted with a flexible wire and wall rosette, as in hanging pushes. The rosette is fixed on the wall, the flexible wire being long enough to allow the push to stand on the table.

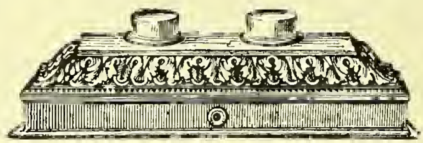


Fig. 676.—Table Push

Stone or plaster walls must be plugged in order to fix pushes securely to them. Sometimes the pushes are sunk into the wall or into the wood panelling, so that the cover is flush with the surface. Occasionally the electric-light switches and the bell pushes in a room are grouped together and covered by a single plate of bronze or other metal, pierced to receive the levers of the switches and the plungers of the pushes.

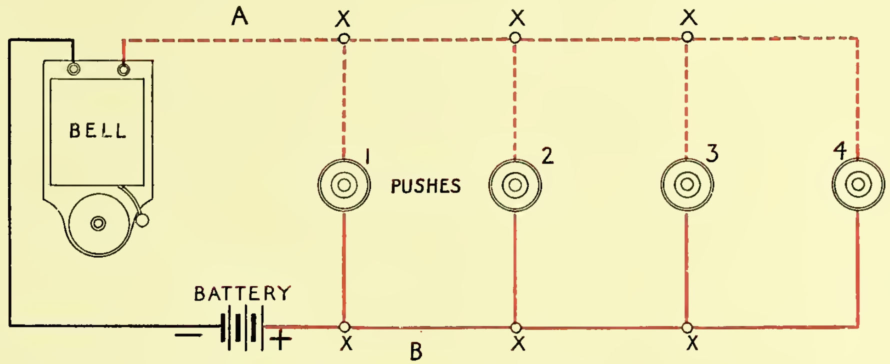
CHAPTER IV

ELECTRIC-BELL CIRCUITS AND INDICATORS

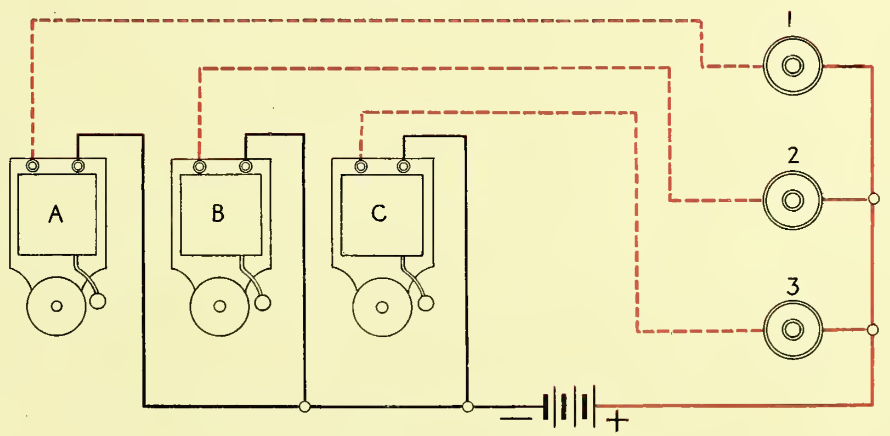
So far we have dealt only with a simple electric-bell circuit, but in most cases a single push is quite insufficient to meet the needs of the user. Even in the smallest house a push is fitted in each of the principal rooms in addition to a front-door push. In some cases they all ring on one bell in the kitchen; in others they ring different-toned bells in order that the servant may identify the call; whilst in larger houses a single bell and an indicator, to be described later, are fitted.

Pushes calling on One Bell.—No. 1, Plate XXXV, is a diagram of the connections where a number of pushes call on one bell. The wires A and B are run to the farthest push, and at convenient points, marked x, wires for the intermediate pushes must be connected. In order to connect the branch wires efficiently, the main wires must be scraped free of insulation at the required point, and the wire to be joined must be twisted tightly around the bare part and carefully squeezed around with a pair of pliers. The joint should then be insulated by wrapping first with indiarubber tape and then with prepared tape.

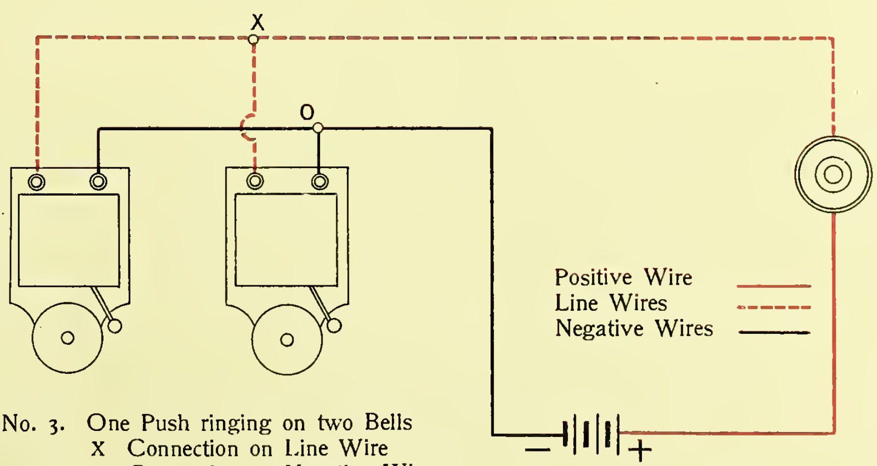
Pushes calling on Separate Bells.—No. 2, Plate XXXV, shows the connections required when each push operates a separate bell. In order



No. 1. Four Pushes ringing on one Bell
A B Main Wire
X X X Connections for Intermediate Wire



No. 2. Three Pushes ringing different Bells



No. 3. One Push ringing on two Bells
X Connection on Line Wire
O Connection on Negative Wire

THREE METHODS OF WIRING FOR ELECTRIC BELLS

to familiarize the fitter with this connection, the following method of procedure is worth committing to memory:—

(*a*) Run one wire from + of battery to one spring of each push, 1, 2, 3;

(*b*) Run one wire from − of battery to one terminal of each bell, A, B, C;

(*c*) From the remaining terminal of the bell run a wire to the remaining spring of the push from which it is required to ring (A to 1, B to 2, and C to 3).

By adopting this method the fitter should have no difficulty in connecting any number of bells to ring from a corresponding number of pushes.

Push calling on Two or More Bells.—It is sometimes required that two or more bells shall be operated from one push. In this case the best method of connecting is shown in No. 3, Plate XXXV, the method of procedure being as follows:—

(*a*) Run one wire from + of the battery to one spring of the push;

(*b*) Run one wire from − of the battery to one terminal of each bell;

(*c*) Run one wire from the remaining terminal of each bell to the remaining spring of the push.

When the push is operated in this case, the current passes from + of the battery to the push and along the wire to X, where it divides, a portion passing through each bell, uniting again at O and thence to − of the battery.

Indicators.—The method of discriminating from which room a call is received, shown in No. 2, Plate XXXV, is satisfactory where there are only a few rooms, but it is obvious that the larger the number of rooms the more difficult will it be to distinguish the different tones of the bells with certainty. In such cases it is usual to fit an indicator in conjunction with a single electric bell, the former serving to provide a visible signal corresponding to the room from which the call has been made.

Indicators externally consist of a shallow hardwood case with an opaque front, in which small apertures are provided corresponding to the number of points from which calls can be received. Each aperture is inscribed with the number or name of the room it represents, such as "Drawing Room", "Dining Room", &c. When a call is received the bell rings, and a coloured disc is caused to appear behind the aperture corresponding to the room from which the call is given. There are many varieties of indicator, but they may be generally divided into three classes, viz.—

(*a*) Mechanical replacement type.
(*b*) Pendulum type.
(*c*) Electrical replacement type.

The mechanical replacement indicator is a type which, although operated by electric current, requires to be restored to the normal position by the attendant pressing a knob at the side of the containing case. Fig. 677 illustrates a complete indicator board for six rooms, and fig. 678 is a detailed illustration of an individual movement. In the latter, *a* is an

electro-magnet; *b* is the armature attached to a pivoted arm *c*; on the under side of *c* a projection *d* is provided; *e* is a disc of metal, about 1 in. in diameter, carried on an arm *f*, pivoted at *g*, and terminating in a tailpiece *h*. The arm *f* carries at its upper end a projection *i*, which normally engages with the projection *d* of the arm *c*. When the electro-magnet is energized, the armature *b*, being attracted downwards, lifts the opposite end so that the catch *d* disengages from *i*, leaving the disc *e* to fall into the indicating position, that is, immediately

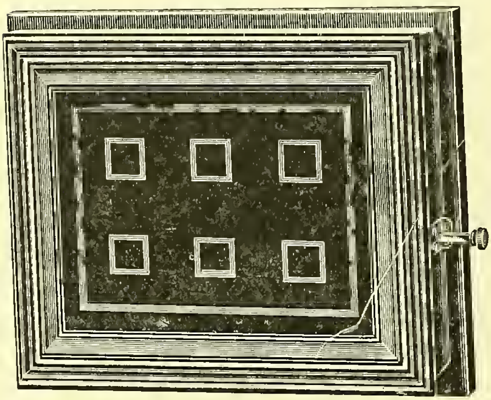


Fig. 677.—Mechanical Replacement Indicator for Six Pushes

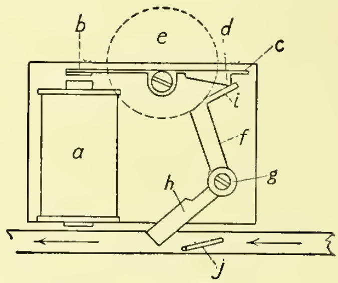


Fig. 678.—Details of Movement in a Mechanical Replacement Indicator

behind the aperture in the front of the board. The replacement of the disc is accomplished by means of a metal rod carrying projecting pins, one for each indicator (*j*, fig. 678). The end of this rod projects through the side of the case and terminates in a small push knob, as shown in fig. 677. The knob, when pressed inwards, causes the replacement rod to move in the direction shown by arrows in fig. 678. The pin *j* presses against the tailpiece *h*, and throws the disc *e* upwards until the projection *i* again engages with *d*, which retains it in position. When the pressure on the knob is removed, the rod regains its normal position by means of a spring.

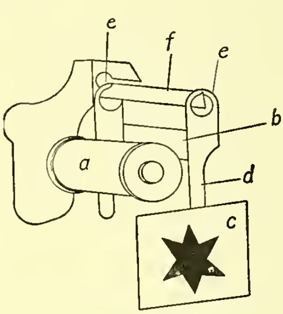


Fig. 679.—Details of Pendulum Indicator

The pendulum indicator is a type in which a disc or flag is caused to swing to and fro across the aperture in the indicator front. There are numerous designs, but that shown in fig. 679 is largely used, and is very reliable. In this illustration *a* is the electro-magnet, *b* an iron armature attached to a stamped metal frame *d*, of such a shape that it terminates at its upper end in two loops *e*, by which it is suspended from the arm *f*, and at its lower end in the flag *c*. The points of contact between *e* and *f* are finished off to a knife edge, so that the armature and flag can swing with as little friction as possible. If the electro-magnet is energized, the armature *b* is attracted and held as long as the current is passing. When the circuit is broken the armature falls back, and the momentum causes the flag to swing to and fro behind the aperture long enough for the servant to observe which indicator

has been actuated.[1] The effect of the swinging flag is increased by means of a dark spot or star printed on its centre. Fig. 680 illustrates a complete pendulum indicator board for six rooms.

The electrical replacement indicator is a type in which the indicating disc is thrown over behind the aperture, where it remains until a

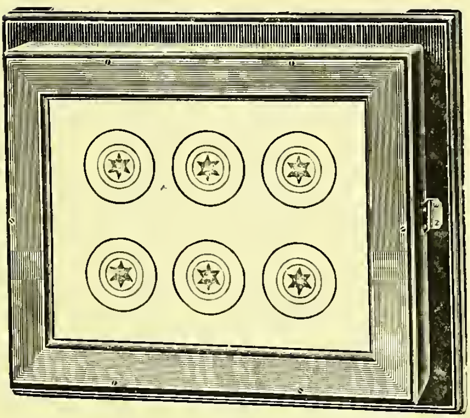


Fig. 680.—Pendulum Indicator for Six Pushes

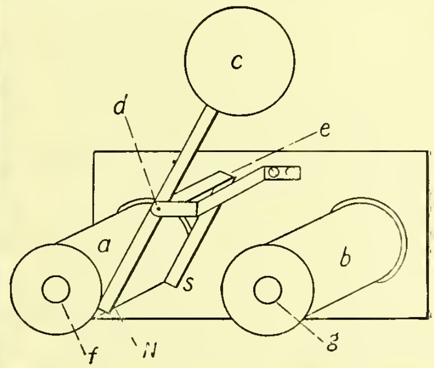


Fig. 681.—Details of Electric Replacement Indicator

push button—which may be at any distance from the board—is pressed. Fig. 681 shows the construction of a well-known indicator of this type. *x* and *b* are two electro-magnets mounted on a brass base; N S is a permanent magnet of the horse-shoe type, carrying the indicating disc *c* and pivoted at *d* and *e*; *a* is the indicating and *b* the replacing electro-magnet.

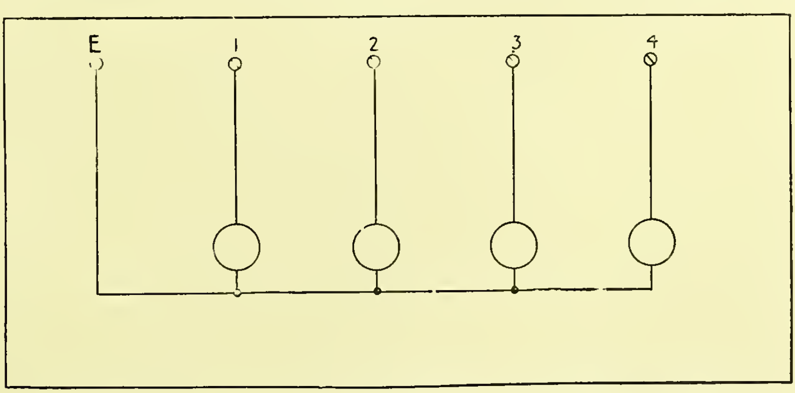


Fig. 682.—Electro-magnet Connections in Mechanical Replacement and Pendulum Indicators

The disc *c* is shown in the normal position. If a current is passed through the electro-magnet *a* in such a direction as to produce a north pole at the end *f* and a south pole at the opposite end, the permanent magnet will be repelled and thrown over till it rests in position against *b*, bringing the disc *c* into the indicating position. If, now, a current is passed round

[1] This is a particularly well-designed pendulum movement, as the armature, extending right along the side of the electro-magnet, is attracted by both ends of the core, and, in fact, the attraction is exerted throughout its entire length.

the electro-magnet *b* in such a direction as to produce a north pole at *g* and a south pole at the opposite end, the permanent magnet will again be repelled and thrown over to the normal position. In indicator boards of the mechanical replacement and pendulum types, the electro-magnets are connected internally as shown in fig. 682. In each movement one end of the electro-magnet wire is connected to a separate terminal, 1, 2, 3, 4; all the other ends are joined together and on a single terminal E common to the whole of the movements.

Fig. 683 shows the manner of arranging the circuits of such an indicator in conjunction with battery, bell, and pushes. 1, 2, 3, and 4 are the indicators, each representing a room, the latter being fitted with pushes, A, B, C, and D respectively; F is the battery and G the call bell. If, now, one of the pushes (say A) is pressed, a current will pass from the + side of the battery to the push contacts, and thence to the terminal

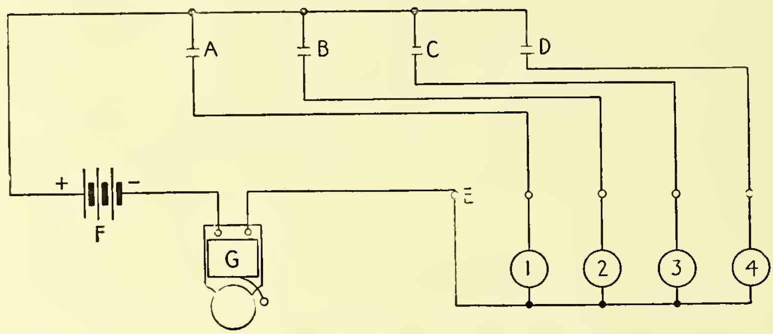
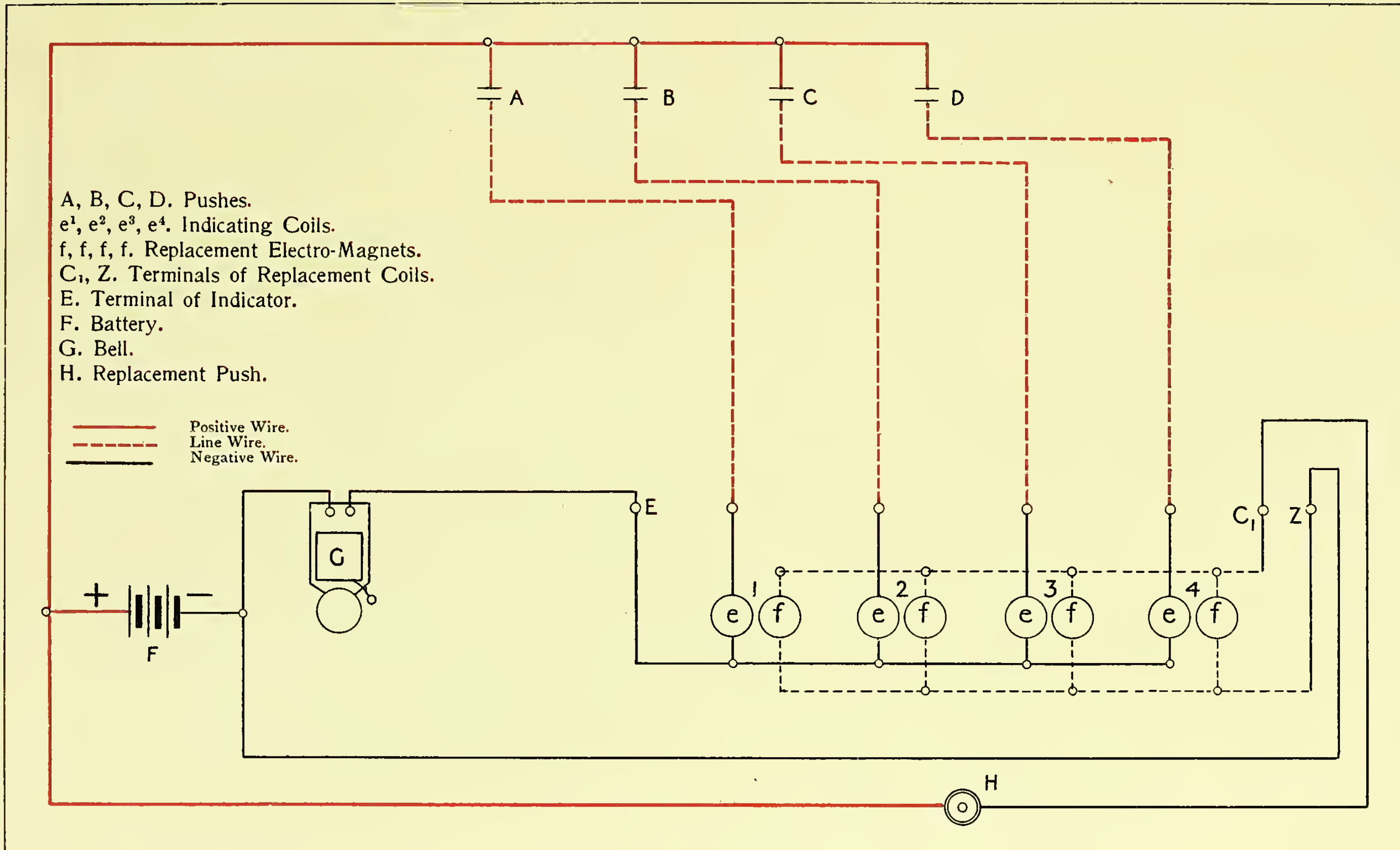


Fig. 683.—Complete Circuit for Pushes with Mechanical Replacement or Pendulum Indicators

and indicator No. 1, and thence from the terminal E through the bell to the − side of the battery. The bell will now ring, and the indicator disc No. 1 will be visible through the aperture of the screen, thus indicating that the call has come from room A.

In electrical replacement indicators the internal connections are arranged as shown by the dotted lines in Plate XXXVI. The indicating coils *e* of the movements 1, 2, 3, and 4 are connected exactly as in fig. 683. The replacement coils, however, are all connected in parallel, and the wires brought to two terminals C and Z. Plate XXXVI also shows how the circuits are arranged for electrical replacement indicators. As stated above, the indicating circuits are exactly the same as in fig. 683. For energizing the replacement electro-magnets *f*, an ordinary push H is provided. When this is pressed, a current passes from the + side of the battery to the terminal C through all the coils *f* in parallel, the terminal Z, the push H, and back to the − pole of the battery. This energizes the whole of the electro-magnets F, and whichever one may be indicating is now thrown over to the normal position.

In electrical replacement indicators for a large number of rooms, the replacing coils are generally arranged in groups with one replacing push for each group, as the battery power required to energize all the replacing coils together would be excessive and not economical.



ELECTRICAL REPLACEMENT INDICATOR AND CIRCUITS

CHAPTER V

BURGLAR ALARMS

The fitting of burglar alarms in private houses is a requirement which will sooner or later be brought under the notice of the electric-bell fitter. The circuits differ little from ordinary electric-bell circuits, the chief point of difference being in the types of circuit-closing devices used. A burglar-alarm system may vary in its extent from a simple attachment to a shop door for the purpose of informing the owner when a customer enters, to a complete equipment for a large mansion, in which every door and window is provided with a device which will cause an alarm to be given on any one being opened. Of the various devices used for this purpose, the following are good examples.

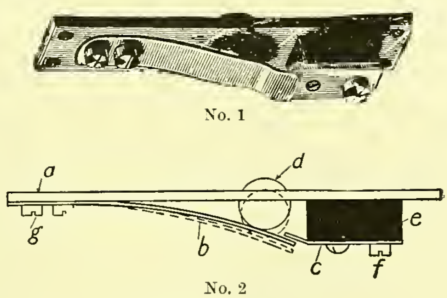


Fig. 684.—Ball Contact

No. 1, View; No. 2, Side Elevation

The ball contact (fig. 684) is for fitting to doors or windows. It comprises a metal plate *a* (for details, see No. 2), to which is attached a flat spring *b*, a contact piece *c*, mounted on an insulating block *e*, and a ball *d*, which projects through the plate *a*, but cannot pass right through it. The connections are made to the screws *f* and *g*. This contact is intended to be fixed in the framework of a door in such a manner that the plate *a* lies flush with the wood, leaving the ball *d* projecting. When the door is closed, its edge presses the ball inwards against the spring *b*, which is forced into the position shown by the dotted lines—that is, out of contact with *c*. Immediately the door is opened, the spring *b* comes forward and makes contact with *c*, thus closing the circuit and operating whatever apparatus may be provided for the alarm.

Applied to a window, the contact is fitted in the sash frame, so that when down the window presses the ball inwards; but when opened, so that the sash rail or stile passes the ball, the contact is made, and the alarm given accordingly. It is advisable to fix this contact in such a position that the window can be opened a certain distance for ventilation without causing an alarm to be given.

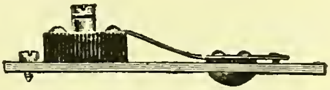
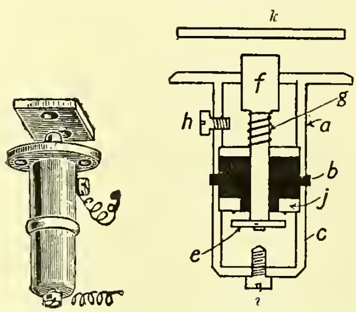


Fig. 685.—Lug Contact

The lug contact (fig. 685) is a window contact only, and is not applicable to doors. It is of similar construction to the ball contact, but the ball is replaced by a semicircular lug of insulating material, which when fitted to a window performs the same function as the ball.

The barrel contact (fig. 686) is for fixing in door jambs or on the bottom of window sashes. No. 2 is a sectional drawing of the details. *a* is a short piece of brass tube with a flange for fixing it, *c* is a second piece of

tube with one end closed. These two are held together by an insulating piece *b*, carrying a brass plate on its upper side in contact with *a*, and a second plate *j* on its under side in contact with *c*. A brass plunger *f*, terminating in a washer *e*, passes right through the insulating piece *b* in such a manner as not to make contact with *j*. The plunger *f* is held out by a spiral spring *g*. In operation the contact is fitted in the window sash, so that the window comes down on the plunger and presses it downwards. The connections are taken from the screws *h* and *i*. When the window is raised, the plunger *f* is pressed upwards by the spiral spring *g* until stopped by the washer *e* making contact with *j*, which closes the circuit and causes the alarms to be operated.



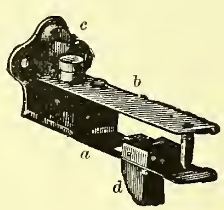
No. 1 No. 2

Fig. 686.—Barrel Contact

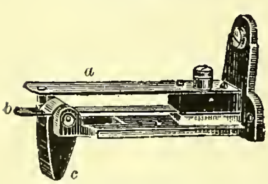
No. 1, View; No. 2, Section

In fitting this contact, the portion of the door or window which comes in contact with the plunger should be provided with a striking plate *k*, otherwise the woodwork will soon wear away and fail to operate the plunger.

Shop-door Contacts.—The contacts described above are all arranged to make contact and keep the alarms ringing until the doors or windows are again closed. This is generally required in private houses, &c., but in the case of an ordinary shop-door alarm the bell is frequently required to give a short ring only as the door is opened. There are two types of contact used for this purpose, one of which gives a short ring as the door opens, and one which gives a short ring both on opening and closing.



No. 1



No. 2

Fig. 687.—Shop-door Contacts

For fitting to shop doors, a type of contact known as a *trigger* is generally used, of which there are two classes, one which rings a bell on opening, whilst the other rings both on opening and closing the door. No. 1, fig. 687, illustrates the former of these. Two springs *a* and *b*, insulated from each other, are fitted to a fixing bracket *c*. The lower spring *a* carries a small lug *d* curved at the back and straight at the front. This lug is fixed on an axis, on which it is free to move in one direction only. The trigger is fixed in such a position that, on opening, the top of the door engages with the lug *d* on its curved side. In pressing forward, the door causes the lug and spring *a* to be pressed upwards, so that contact is made between *a* and *b*. When the door closes, it engages with the lug *d* on its flat side, and, in passing, the latter, moving on its axis, is lifted up out of the way without lifting the spring *a*. When the door has passed, the lug falls into the normal position in readiness to be operated again. No. 2 illustrates a trigger to ring on either opening or closing a door. This is provided with two springs *a* and *b* and a lug *c*.

The latter in this case is arranged to move on its axis in either direction, and in doing so causes the springs a and b to make the necessary contact.

Continuous-ringing Bells.—It sometimes happens that the bell is required to ring continuously when a door is opened, even although it may be closed again immediately. In this case a continuous-ringing bell is used, which once started will continue to ring even after the circuit has been broken at the actuating contact. Such a bell is illustrated in figs. 688 and 689, the former showing the bell with cover, whilst the latter shows the details. The chief difference between this and the ordinary type of electric bell is that it is provided with a small lever at the side, which drops when the circuit is first closed and closes a separate set of contacts which keep the bell ringing independently of the contact device which started it.

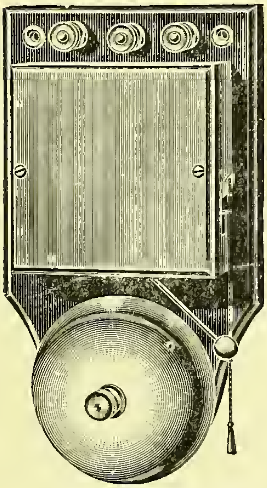


Fig. 688.—Continuous-ringing Alarm Bell

In fig. 689 e is a pivoted lever which normally engages with a catch h of the armature, in which position it is held in tension by a spiral spring i. Three terminals, L, C, and Z, are provided, denoting "line", "carbon", and "zinc" respectively. When the push button P is operated, a current passes from the + side of the battery to the terminal C, through the coils of the electro-magnet a to the contact pillar b, armature spring c, frame d, and terminal L, and through the line wire to the push P, and back to the − side of the battery. The circuit thus closed energizes the electro-magnet, causing the armature to be attracted, releasing the lever e, which is pulled by the spring i into the position shown by the broken lines. In this position it presses a flat spring f into contact with a separate insulated contact

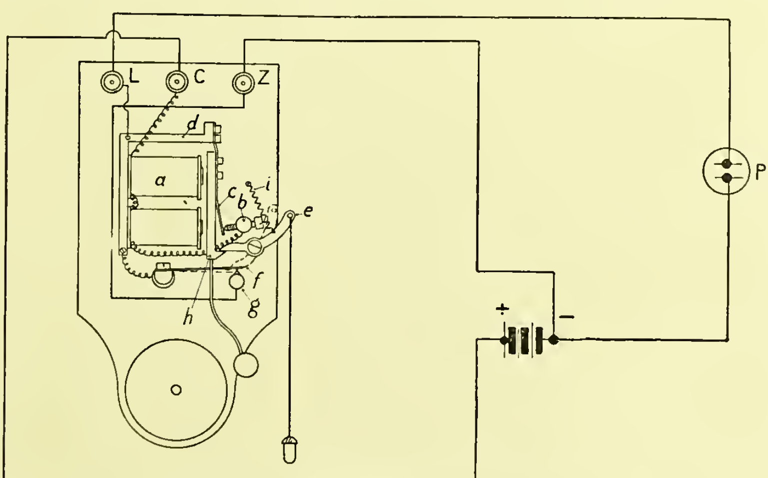


Fig. 689.—Details of Continuous-ringing Alarm Bell

stud *g*, thus closing a circuit quite independently of the push. The circuit is now as follows:—+ of battery to terminal C, electro-magnet *a*, contact pillar *b*, armature spring *c*, frame *d*, spring *f*, contact stud *g*, terminal Z, and − of the battery. It will thus be seen that once the bell has been started by the push P, it will continue to ring, even though the circuit is afterwards broken at that point, until the lever is pulled into its normal position. The circuit being now broken both at P and at *f*, *g*, the armature falls back and engages with *e*, in which position it remains until the push P is again operated.

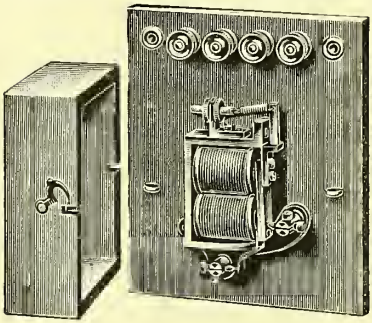


Fig. 690.—Relay for Open-circuit Systems

Circuits. — Large systems of burglar alarms differ only from electric-bell systems in the types of contact devices used. The circuits of one are practically the circuits of the other. The connections given in the previous pages, however, deal only with what are known as *open-circuit* systems—that is, systems which depend on the closing of a circuit to give an alarm. One objection to such systems is that if a wire breaks, or if the marauder cuts the wires, the system breaks down. To overcome this, the *closed-circuit* system, in which the giving of an alarm is caused by the breaking of the circuit, has been devised. This involves the use of special apparatus, the chief of which are a special relay and a constant-current battery, in addition to the ordinary electric-bell equipment.

A relay is designed primarily for the purpose of signalling over long lines where the current arrives at the receiving end so weakened by the line resistance as to be insufficient to operate the ordinary types of electric

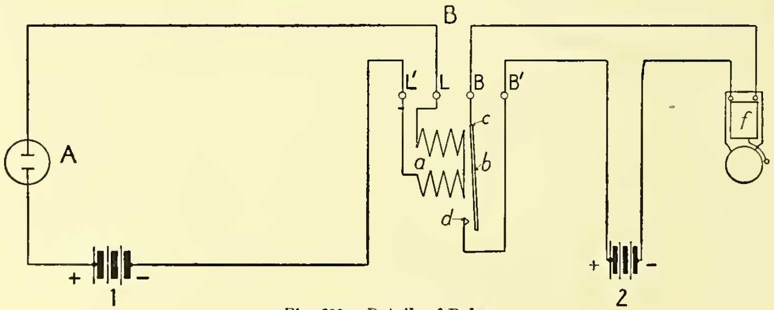


Fig. 691.—Details of Relay

bells or other signalling apparatus. The relay, being more delicately constructed, responds more readily to weak currents, and is arranged so that its armature, when attracted, closes a local circuit in which the apparatus to be operated is included. Fig. 690 illustrates an ordinary type of relay for open-circuit work, and fig. 691 shows the details of construction and circuits. In fig. 691 *a* is an electro-magnet, *b* an armature pivoted at *c*, *d* a contact screw generally fitted to the same metal frame as the electro-magnet, but insulated from it. The ends of the electro-magnet *a*

terminate in two terminals L, L′; the metal frame of the relay and the contact screw *d* are connected to the two terminals B, B′. The connections in fig. 691 represent a simple circuit in which the calling point is removed some distance from the point at which the call is to be received. When the circuit is closed at A, the current passes from + of battery 1 to the push, the line terminal L, the electro-magnet *a*, and the terminal L′, and through the return wire to − of battery 1. As a result the electro-magnet *a* is energized, and the armature *b* is attracted and drawn into contact with *d*, closing the following circuit: + of battery 2 to terminal B′, contact *d*, armature *b* to and through the bell *f*, and so on to − of battery 2. The bell *f* will consequently ring as long as the contact device at A is in operation, but immediately the circuit is broken the armature of the relay falls back into its normal position, and the bell ceases to ring.

The closed-circuit relay is of similar construction, but the contact *d* is placed at the back of the armature *b*, so that when the electro-magnet is not

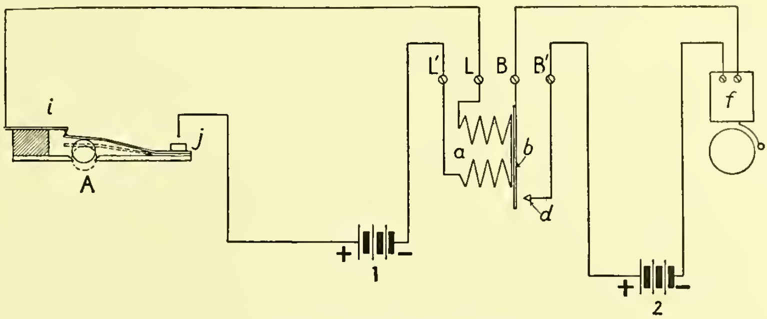


Fig. 692.—Closed-contact System

energized they are in contact with each other. The contact devices must be arranged to operate in the opposite manner to those shown in figs. 684 and 685; that is to say, when a door or window is closed the circuit must be *completed* through the contact. Fig. 692, illustrating a simple closed circuit system, shows the arrangement of the various parts. A is a contact device shown making contact between *i* and *j*, that is, in the position in which they would be if the door or window were closed. In this position a circuit is established continuously as follows: + of battery 1, contact springs *j* and *i*, line wire to terminal L, electro-magnet *a* of relay, terminal L, and back to − of battery 1. The electro-magnet *a* is continually energized, and the armature *b* attracted. Should the door or window at A be opened, the contact between *i* and *j* is broken, the electro magnet *a* is de-energized, and the armature *b* is released and falls back into contact with *d*, closing the following circuit: + of battery 2, terminal B′, contact *d*, armature *b*, terminal B, bell *f*, and back to − of battery 2. As a result, the bell will ring until the line circuit is again completed. It will be obvious that anything which causes a break in the line circuit will have the same result as actuating the contact device, so that an intruder, thinking to avoid detection by cutting the wires in the circuit in which the contact device is placed, would quickly find that he had been cherishing a vain delusion.

In the event of **indicators** being required for closed-circuit systems, they would probably require to be specially constructed, as each movement would have to operate as a closed-circuit relay. In such a case the fitter cannot do better than consult a good manufacturing firm, who would doubtless be able to offer a suitable apparatus.

The selection of **a suitable battery** for closed-circuit systems is a very important item, as there are very few which will stand the test of a continuous circuit for any reasonable length of time. The "Primax" (fig. 693) and the "Edison Lalande" cells will both be found to be very suitable for the purpose.

These cells, on account of their low internal resistance, have a large output of current, which enables them to maintain their efficiency under a steady discharge for a considerable period. They are made in various sizes and corresponding capacities. The size known as having a capacity of 300 ampere-hours is a very serviceable cell to use. This means that with an output of 1 ampere per hour it will last for 300 hours without attention. Thus on a closed circuit having 100 ohms external resistance and a battery of 10 volts, we find by Ohm's Law $\left(C = \frac{\text{E.M.F.}}{r} = \frac{10}{100} = \cdot 1\right)$ that there will be ·1 of an ampere passing through the circuit. The battery will therefore last on closed circuit ten times as long as if 1 ampere was passing. In other words, such a system would run for 125 days of 24 hours each, or allowing that the system would be disconnected during 12 hours of daytime out of each 24 hours, then the system would run for 250 days, roughly 8 months, without attention.

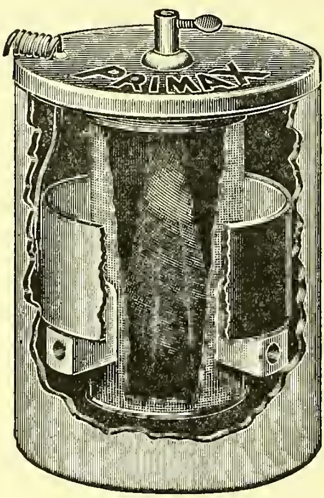


Fig. 693.—"Primax" Cell

It is of course inevitable that the broad general lines as suggested here will sometimes require modification, and possibly little intricacies may have to be introduced to meet the special ideas of a particular client. In such cases, if unable to devise a method of meeting the requirements, the fitter is advised to consult the suppliers of apparatus, who are, as a rule, pleased to advise a possible customer.

CHAPTER VI

FIRE ALARMS

Fire alarms are, as a rule, required in large public institutions, such as asylums, hospitals, and public schools. They may be classed under two headings, viz.: (*a*) mechanically operated alarms, and (*b*) automatic alarms.

Mechanically Operated Alarms.—In the first class are included a great variety of circuit-closing devices, enabling a person first observing a fire to operate the alarms. Some of them are in reality nothing more or less than electric-bell pushes of superior construction, in most cases protected from accidental or wilful injury. A few of the best-known types are illustrated. No. 1, fig. 694, shows a brass push of the barrel type, 4 in. in diameter, having the instructions for use inscribed round the rim, and being fitted with a glass front held in position by a brass ring which screws on to a screw thread cut on the edge of the push. This has a very good appearance, particularly when mounted on a polished wood block. No. 2 shows a type of alarm contact sometimes preferred. It comprises a hardwood electric-bell push, mounted inside a teak case, with lock and key. A glass front is provided to the door, and carries behind it a printed card of instructions for use. In these two contacts the method of giving the alarm is to break the glass and press the push button.

No. 1

No. 2

Fig. 694.—Fire-alarm Pushes

In another type of alarm contact the breaking of the glass alone is sufficient to give the alarm. It consists of a cast-iron box with a glass front, and has the contacts so arranged that the circuit is closed by the plunger in the centre moving forward. Normally the plunger is held pressing against the glass front by means of a spiral spring. Immediately the glass is broken the plunger moves forward, causing the circuit to be completed inside the box. A small hole is drilled in the centre of the glass, which enables the lines to be tested without opening the alarm. This is accomplished by arranging the alarm contacts so that the circuit can also be closed by pressing the plunger inwards. Consequently, when a small steel pin is inserted through the hole, and pressure exerted on it, the plunger is pushed back, closes the contact, and operates the fire-alarm circuits. The example of this type of contact illustrated in fig. 695 is considered superior to any other alarm of this type for various reasons. Firstly, its construction is very substantial and reliable; and secondly, it is so arranged that the front can be opened without causing the alarms to ring, and a separate test push is then accessible for making test calls.

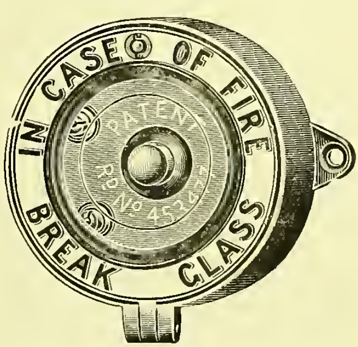


Fig. 695.—Fire-alarm Contact Operated by Breaking the Glass

Automatic fire alarms are apparatus in which the alarm circuits are closed by the rising of temperature in proximity to the alarm device.

Possibly the simplest form of such devices is that shown in fig. 696, which consists of an ordinary thermometer having a platinum wire fused into the mercury bulb, and another into the top of the tube reaching down to the degree at which the alarm is required to operate. The chief objection to this type is that the rising temperature does not act directly on the mercury, so that some time must necessarily elapse before the alarm is given. There are at present two very good types available in which this objection is overcome. These are the May-Oatway and the Pearson automatic thermostats.

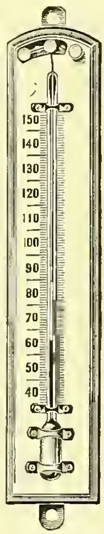


Fig. 696.—Simple Automatic Fire Alarm

The May-Oatway thermostat (fig. 697) depends for its action on the expansion of a suspended wire, A, when subjected to the influence of heat. This wire may be of any length; that adopted for use is about 7 ft. It is suspended near the ceiling and supported at each end. At the centre a small cone-shaped "bob" of carbon is suspended by a chain, and normally rests immediately above two platinum-tipped contact springs, E and F. When the temperature rises, the suspended wire lengthens appreciably, causing a sag in the centre, as shown by the dotted line B. At this point, therefore, the wire is automatically lowered, causing the carbon bob to drop on to and make contact across the contact springs E and F, and thus close the alarm circuit. One end of the wire A is fixed to a pivoted plate D, the pivot being a screw shown at the right-hand corner of the plate. This is to allow the thermostat to be tested. By pushing the plate D upwards by the left-hand corner, the wire is lowered into the dotted-line position, closing the circuit and thus testing all the units of the system. In actual practice the wire and contacts are mounted on a bar of iron, the inventors claiming that by this arrangement a compensatory effect is provided which allows a narrow margin of adjustment such as cannot be allowed in the case of thermostats without a compensation device.

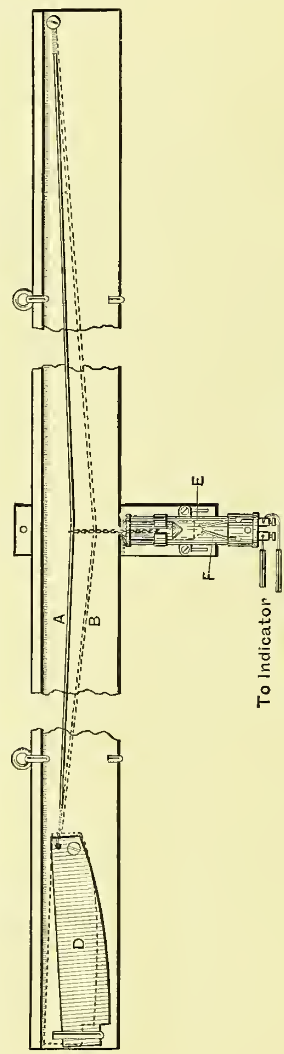
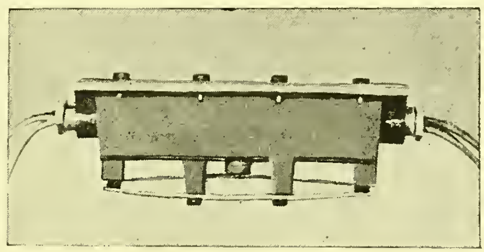


Fig. 697.—The May-Oatway Thermostat

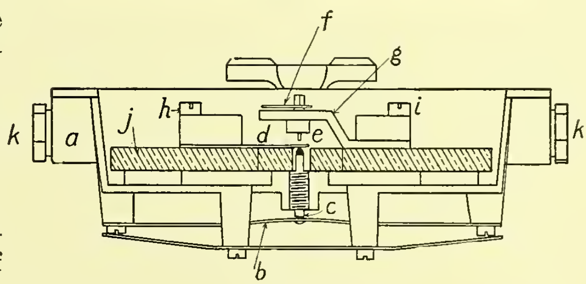
It will be obvious that any thermostat intended to give an alarm at a fixed degree will always operate when that degree is reached. In a room,

therefore, which is naturally subjected to great variations of temperature the degree must be fixed so as to allow a margin well above the maximum. In some cases this may be objectionable. Suppose that a room, when in use, reaches a temperature of 70°. At night, when fires and lights have all been extinguished, the temperature may fall as low as 35°. A thermostat without compensation arrangements would require to have its contacts fixed at a minimum of (say) 90°, allowing a margin of 20° above the maximum. At night, when the temperature is (say) 35°, a fire breaking out will have to increase the temperature by 55° before the thermostat operates, whereas an increase of 20° above the normal *should* signify danger.

According to the claims of the inventors of the May-Oatway thermostat, this objection is overcome, as stated above, by mounting the expanding wire on an iron frame. In ordinary use the temperature of a room increases gradually, and the iron bar as well as the wire expands, thus keeping the relative adjustments at the same safety margin. If, however, a fire breaks out suddenly, the wire, being of much smaller bulk than the iron bar, lengthens immediately, and performs its function before the iron bar, owing to its much greater mass, has had time even to become warmed up.



No. 1



No. 2

Fig. 698.—The Pearson Automatic Thermostat

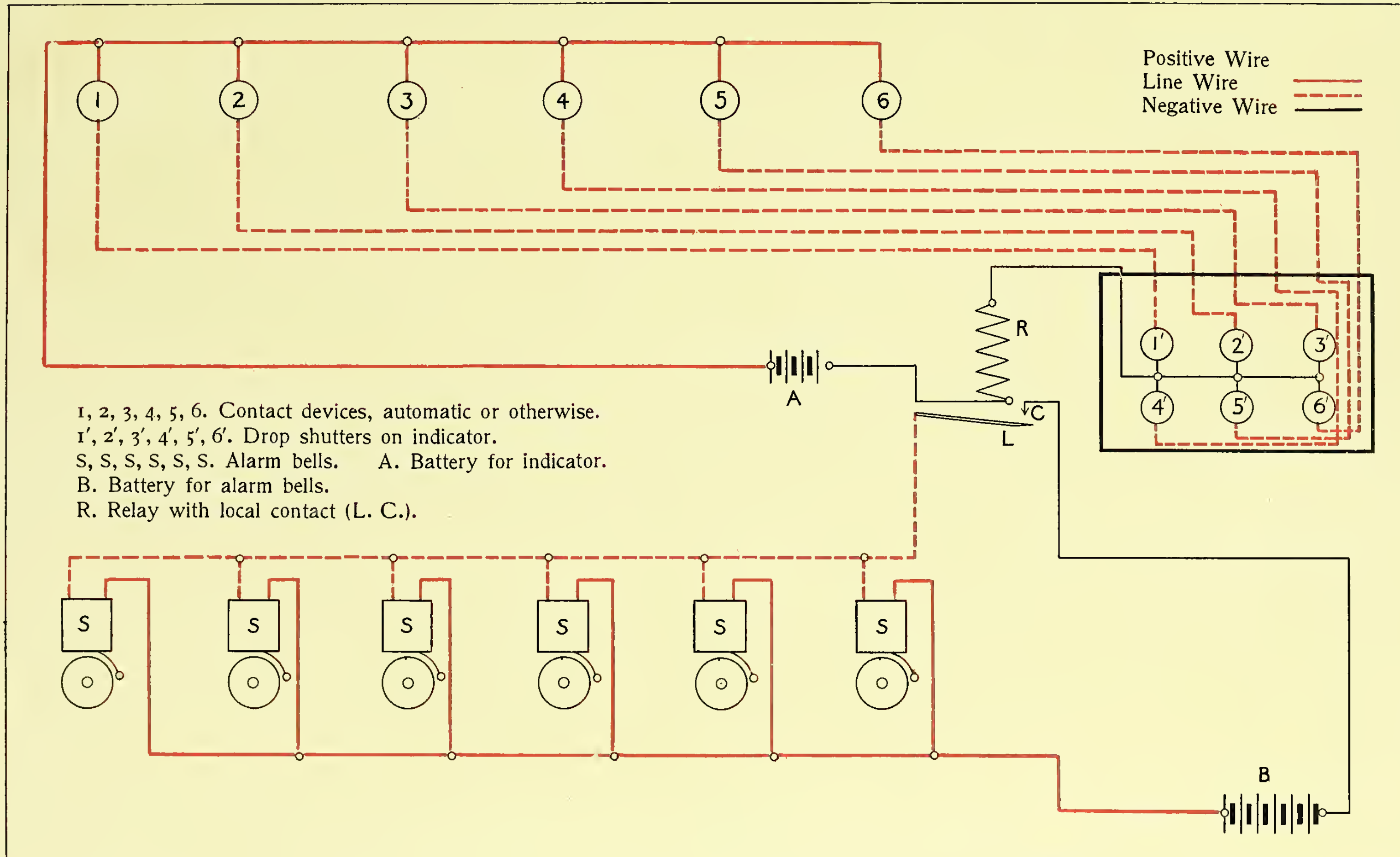
The Pearson automatic thermostat (fig. 698) embodies the same principles as the May-Oatway type, in so far as it depends upon the expansion of metal causing an alarm to be given. It is built in the form of an oblong iron chamber or box *a*, approximately 5 in. by 2 in. by 1½ in. This box carries on its under side, fixed rigidly to it, a thermal strip *b* having a pin *c* fixed at its centre. This pin passes through a stuffing-box to the interior of the iron chamber, which contains an insulating base *j*, carrying the block *h* in connection with a flat spring *d*, and the block *i* in connection with a cock piece *g*. The elevated part of this cock piece carries a screw *e*, which has its point resting opposite the end of *d*. This screw forms the means of adjusting the thermostat, which is accomplished by screwing it forward or backward as required. A pointer *f* mounted on the screw *e* is arranged to move over a small graduated scale, and serves as a guide to the adjustment, the scale being divided off in degrees Fahrenheit. The screw *c* is provided

with a point of insulating material at its inner end, which presses against the spring *d*. No. 2 shows the normal position of the parts. Under the influence of heat the thermal strip *b* expands, and slightly increases in length. As it is fixed rigidly at each end, the increase in length has to be taken up at its centre, which causes it to bend upwards at that point, pushing the pin *c* upwards until the spring *d* is pressed into contact with the point of the screw *e*. This occurs immediately the temperature reaches a predetermined degree. It will be apparent that the distance between the point of *e* and the contact spring *d* is the governing factor of sensitiveness. By turning the screw *e* it is possible to adjust the instrument so delicately that the heat of the hand or breath will operate it. The contacts being well protected, this thermostat is particularly suitable for damp or dusty situations.

Bells and Indicators.—In devising a system of fire alarms for the protection of a building, the fitter must be largely guided by the requirements of the particular building, and also to some extent by the depth of his client's purse; although, if fire alarms are considered necessary, the question of cost should be a secondary consideration. The simplest form of alarm is to have the thermostats or other contact devices connected in electrical circuit with a loud-sounding bell which will be heard all over the building. This might be sufficient for use in small buildings, but considerable difficulty would be experienced in obtaining a bell which would sound throughout a large building. Consequently, it is becoming more usual to arrange a number of smaller bells scattered about the premises, all of which will ring on a thermostat or other device being operated. In some cases an audible fire signal would be considered sufficient, but in large buildings much time would be lost in ascertaining the locality of the outbreak. It is therefore necessary to fit an indicator in a position where there is generally someone in attendance, so that an outbreak of fire is not only notified on the bells, but is actually located by the indicator.

In some cases the ringing of fire bells throughout a building may be considered objectionable. In an asylum, for example, the ringing of fire bells would be likely to cause a serious panic amongst the helpless inmates. In such a case it is best to arrange that the fire bells should ring only in the quarters of the men deputed to deal with an outbreak. They are thus able to take the first steps for coping with the difficulty, unhampered by frantic men and women, whilst care is taken to inform those in charge of the various wards to take whatever preliminary steps may be necessary for the safety of the inmates.

The circuits of fire-alarm systems are practically the same as for electric bells. It is therefore considered sufficient to illustrate only a system such as that suggested above, where the locality of the fire is indicated at a central point, and alarm bells are operated in different parts of the building. Such a system is shown in Plate XXXVII. In this diagram 1, 2, 3, 4, 5, and 6 are contact devices, either automatic or mechanically operated; 1′, 2′, 3′, 4′, 5′, and 6′ are drop shutters of an indicator; S, S, S, S, S are alarm bells; R, a relay with local contacts L C; A, indicator battery; B, battery for alarm bells. When an alarm contact is operated, the circuit of



FIRE-ALARM BELLS

battery A is closed through the contact, line, indicator, and relay. The indicator falls, and the armature of the relay is drawn into contact with the contact point *c*. This closes the circuit of battery B through all the fire bells connected in parallel. In order that these may ring efficiently, even although separated from each other by a considerable distance, they must be wound to a high resistance. This resistance should be increased as the number of bells increases; for example, five bells should be not less than 50 ohms each, whilst ten bells should be of 100 ohms in order to ensure reliability. The battery B should be of the six-block agglomerate type. Twelve such cells would safely ring ten 100-ohm bells connected as shown in Plate XXXVII.

CHAPTER VII

THE BELL TELEPHONE

To Professor Alexander Graham Bell must be ascribed the honour of being the inventor of the electric telephone. The principle on which the original Bell telephone was designed is that propounded by Professor Faraday, viz.: "That the movement of an electrical conductor in a magnetic field, in such a manner as to cut the lines of force, causes current impulses to be generated in such conductor". Inversely, if the conductor is stationary, and magnetic lines of force are caused to move through or across the conductor, similar current impulses are generated. An illustration of this rule will make the principle quite clear. In fig. 699 *a* is a coil of very fine wire wound upon a reel, with a hole in the centre. If a bar magnet *b* is suddenly introduced into the centre of the coil, as shown, a single current impulse is generated, owing to the action of the magnetic lines of force cutting through the turns of wire forming the coil. This current impulse passes in a certain direction. The sudden withdrawal of the magnet will give rise to a second current impulse, which, in this case, passes round the coil of wire in the opposite direction to the first. This is due to the fact that the lines of force pass across the turns of wire in the opposite direction to that in which they passed when the magnet was introduced into the coil. If the magnet is allowed to remain stationary in the coil, a large number of lines of force will cut through the turns of wire. Any medium which causes these lines to assume a position different from the normal will, owing to their movements through the turns of wire, give rise to current impulses in the conductor. The introduction of a piece of iron will be sufficient to accomplish this. Fig. 663, p. 306, shows the effect of introducing a piece of iron into the magnetic field, and if compared with fig. 660, p. 305, it will be readily observed how the lines of force are caused to deviate from their normal position. To make this

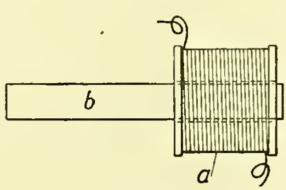


Fig. 699.—Coil of Wire and Bar Magnet

principle quite clear, we may assume the case of two individual lines of force. In fig. 700 *a* is a coil of fine wire wound on the end of a permanent magnet *b*. Nos. 1 and 2 are assumed to be two lines of force, shown resting in their normal position. If a piece of iron *d* is placed in front of the magnet, Nos. 1 and 2 will be deflected from their normal position, as shown by the broken lines 1′ and 2′. In making this deflection, the lines 1 and 2 pass through a considerable number of turns of wire, and generate a current impulse therein. If the iron is now removed the lines of force regain their normal position, and, in so doing, cut the wire in a direction opposite to the first, causing a current to be generated also in the opposite direction. If, instead of taking *d* away, we approach it nearer to the magnet, as shown by the broken lines *d′*, the deflection will be greater still, as at 1″ and 2″, and again we have the movement of lines 1 and 2 through a number of turns of wire. Bring *d* back to its original position, and the lines 1 and 2 assume the positions 1′ and 2′, again cutting the turns of wire in the opposite direction. It will be seen, therefore, that by moving the iron to and fro between the positions *e* and *f*, the lines 1 and 2 are kept in continual motion, moving in alternate directions, the result being the generation of alternating currents of electricity. It follows, therefore, that if a coil of fine wire is permanently fixed within a magnetic field, any medium which causes the lines of force to alter their position will cause currents to be generated, the direction of which will depend on the direction in which the disturbance takes place

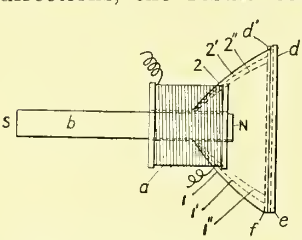


Fig. 700.—Permanent Magnet wound with Wire, and Piece of Iron

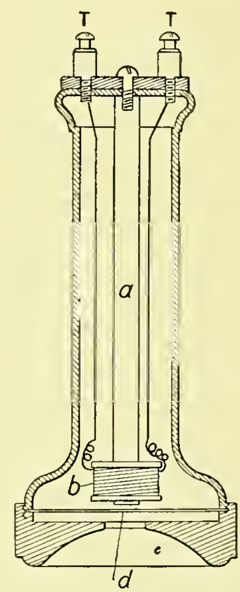


Fig. 701.—Bell's Original Telephone

Fig. 701 illustrates a sectional view of Bell's original telephone, in which the above principle is utilized; *a* is a permanent magnet, *b* a coil of very fine wire the ends of which terminate in binding posts TT, *d* is a circular diaphragm of iron, held firmly in position by the mouthpiece *c*. This mouthpiece has a hole in the centre, which leaves the central portion of the diaphragm exposed. The diaphragm is, therefore, in the same position relative to the magnet *a* as the piece of iron *d* in fig. 700. Considering figs. 700 and 701 together, it will readily be seen that the diaphragm *d*, placed in front of the magnet *a*, will have the effect of deflecting the lines of force from their normal position. If, now, the diaphragm *d* is caused to vibrate rapidly to and fro, the lines of force will be subjected to oscillations of equal rapidity, and these oscillations taking place across the turns of the coil *b* will cause electric currents of alternating direction to be generated therein in the manner described above. Such vibrations of the diaphragm *d* are readily set up by direct-

ing the voice through the hole in the mouthpiece *c*, so that the sound waves impinge on the centre of the diaphragm. The resulting alternations of current will have a frequency exactly equal to that of the vibrations peculiar to the sound by which the diaphragm is agitated. The Bell telephone illustrated in fig. 701 is, therefore, in reality a current generator for converting sound vibrations into alternating electric currents, which are capable of being transmitted over a considerable distance.

For receiving and transforming the alternating currents into audible sounds a similar telephone is used, and its action will be understood from fig. 701. Suppose that, instead of a permanent magnet, a plain soft-iron bar is used. If a battery current is passed through the coil *b*, the iron bar will become magnetized, producing a north pole at one end and a south pole at the opposite end. We will assume that the current passes in such a direction as to produce the north pole at the end near the diaphragm. If the battery connection is now reversed, so that the current passes round the coil in the opposite direction, the polarity of the magnet will be reversed,

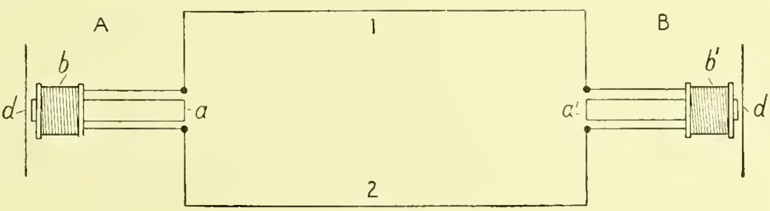
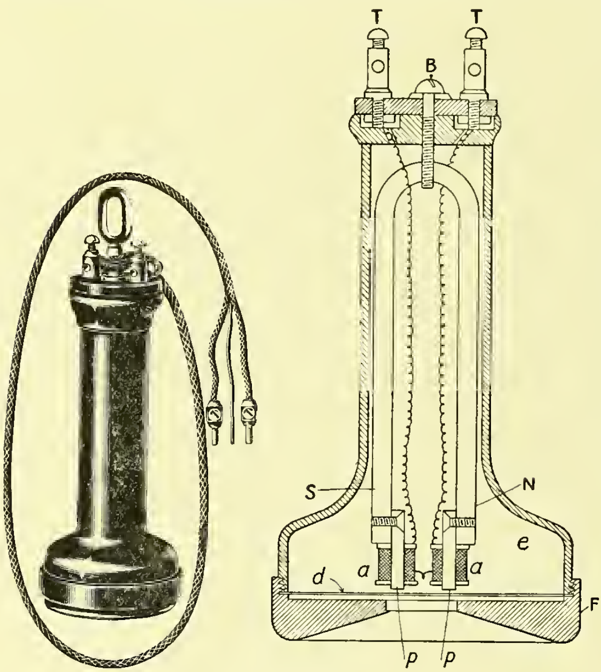


Fig. 702.—Two Bell Telephones connected together

producing a south pole at the end nearest the diaphragm and a north pole at the opposite end. Replacing the iron bar by the permanent magnet, with its north pole near the diaphragm *d* (fig. 701), the latter, by reason of the pull exerted upon it by the magnet, will receive a slight buckle inwards. If a battery is connected to the coil in such a manner that the current passes in the same direction as produced a north pole at the diaphragm end when a plain iron bar was used, the magnetic field of the permanent magnet will obviously be augmented and strengthened, so that the diaphragm is attracted farther towards the end of the magnet. If, however, the current passes round *b* in the opposite direction, that is, in the direction which produced a south pole at the diaphragm end of the plain iron bar, then the magnetic field of the permanent magnet will be weakened, and this reducing its attracting influence on the diaphragm *d*, the buckle which the latter normally receives will be reduced, having the effect of moving the diaphragm slightly away from the magnet. Thus, by a single alternation of current round the coil *b*, a single "to-and-fro" oscillation of the diaphragm *d* has been produced.

Now imagine **two Bell telephones connected together**, as in fig. 702. For simplicity, the casings of the telephones are omitted. When the diaphragm of the telephone at A is spoken against, the resulting alternating currents generated in *b*, passing through the connecting wires 1 and 2, and round the coil *b'* at B, will cause rapid variations in the strength of

the magnet *a′*, which variations will cause a corresponding agitation of the diaphragm *d′*. When, therefore, the person at A holds the telephone to his mouth and speaks, while the person at B holds the telephone to his ear to listen, the cycle of events is as follows. A's voice projected against the diaphragm *d* causes it to vibrate in unison with the sound vibrations; these vibrations are transformed into electrical energy, which, in the form of rapidly alternating currents, are conveyed by the wires 1 and 2 to the coil *b′* of B's telephone, where they are retransformed through the diaphragm *d′* into sound vibrations, which reach B's ear, having a frequency and amplitude corresponding to the sound vibrations originated by A.



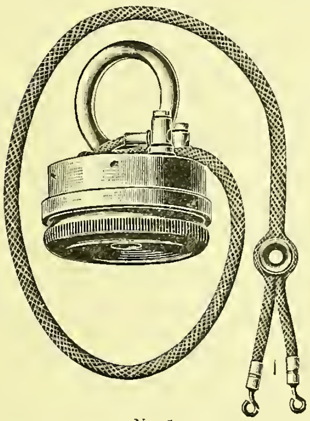
No. 1 No. 2

Fig. 703.—The Double-pole Bell Receiver

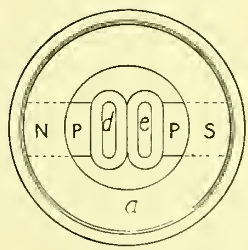
Modifications. — The arrangement above described was, for a considerable time, considered the acme of perfection, although many successful attempts were made to improve the speaking qualities. Such attempts, for the greater part, consisted of modifications in the form of magnet used, in order that the diaphragm should rest in as powerful a magnetic field as possible. As it would occupy too much space to describe them all here, and would serve no useful purpose, it is sufficient to describe in detail the three types which have survived, and which will be most frequently met in general practice. These are the Double-pole "Bell", the "Ader", and the "Watch" Receivers.

The Double-pole Bell receiver is illustrated in No. 1, fig. 703, and is shown in section in No. 2. NS is a permanent magnet of horse-shoe shape having at its extremities two soft-iron extensions *pp*, termed *pole pieces.* These pole pieces, if taken separately, are not magnetized, but, being in contact with the permanent magnet, they become magnetized for the time being, and operate in exactly the same manner. Being of soft iron, they are more susceptible and respond more readily to the magnetic variations caused by the speaking current. On each pole piece a coil of fine wire *a a* is wound, one end of one coil being joined to one end of the other, and the two free ends being connected to the binding posts T T. The magnet N S, with its pole pieces and coils, is fitted in an ebonite casing,

and held in position by a screw B. The diaphragm d is placed on the edge of the casing e, after which a cap F is screwed on, effectually clamping the diaphragm in a position close to but not touching the pole pieces pp of the permanent magnet. In this position the diaphragm is in a very powerful magnetic field, and will respond to currents of infinitesimal strength. The distance between the diaphragm and the pole pieces of the magnet



No. 1



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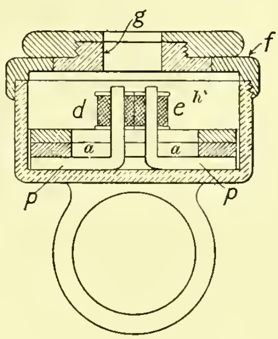
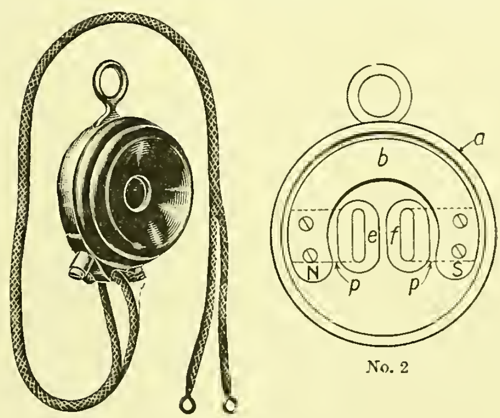


No. 3

Fig. 704.—The Ader Receiver

should be so arranged that, even when the former is subjected to the most violent vibrations, it cannot possibly touch the latter. Some manufacturers simply arrange the depth of the containing case to effect this purpose, whilst others grind the edge of the case quite flush with the pole pieces, and then place a thin metal ring on the edge before placing the diaphragm in position. The latter method ensures a uniform adjustment, but is also sometimes the cause of trouble, as inquisitive persons, unscrewing the cap of the receiver, are apt to lose the ring or replace it on the wrong side of the diaphragm, in which case the latter, when placed in position, is hard on the magnet, so that it cannot respond to the vibrations.



No. 1

No. 2

Fig. 705.—The Watch Receiver

The Ader receiver (fig. 704) is a very compact and efficient type. The details are shown in Nos. 2 and 3, which represent respectively a plan view with the cover removed and a sectional view complete. The permanent magnet a is circular in form and is polarized, so that its poles are at N and S. From these points the two pole pieces P P extend towards the centre of the ring, and terminate in the coils of wire d and e. The diaphragm h is held in position by the metal cover f. A distinctive feature of the Ader

receiver is that on the inside of the cover a massive iron ring *g* is fitted, the object being to attract a large number of lines of force through the diaphragm, and thus increase the strength of the speaking currents. To further increase the strength, two or more magnets are used, placed in such a position that the like poles are together. No. 3, fig. 704, shows two magnets so arranged.

The Watch receiver, which is designed for both compactness and cheapness, is illustrated in No. 1, fig. 705, and shown in detail, with the cap removed, in No. 2. *a* is the containing case, *b* the permanent magnet of semicircular shape, having its north and south poles terminating in the pole pieces *p p*, the latter carrying the coils of wire *e f*. The diaphragm is held in position in the same manner as in the Bell and the Ader receivers, and, as will be readily understood, it operates in a similar manner.

CHAPTER VIII

MICROPHONES AND INDUCTION COILS

The telephones described in the previous chapter were at first used both as receivers and transmitters, but, the currents generated being necessarily small, the distance over which efficient telephony was possible was somewhat limited.

The advent of **the microphone** (invented by Professor Hughes) changed the condition of affairs by providing at once a transmitting apparatus, which

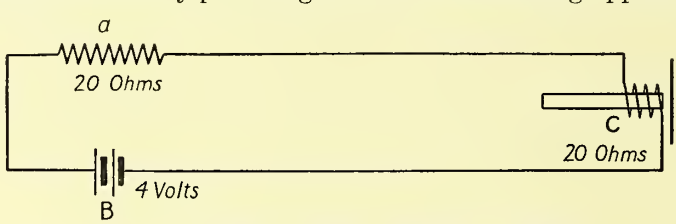


Fig. 706.—Bell Telephone with Battery and Resistance Coil

allowed comparatively powerful currents to be used to operate the receiving telephones. The principle of the microphone is that of a varying resistance, connected in circuit with a battery and receiver, such variations causing stronger or weaker currents to pass, resulting in varying changes in the strength of the magnet of the receiver. A simple illustration will serve to make this clear.

If a Bell telephone C (fig. 706) of (say) 20 ohms resistance is connected to a battery B, having an E.M.F. of 4 volts, with a resistance coil *a* of (say) 20 ohms in series, then, working out by Ohm's Law (see p. 302), and omitting the internal resistance of the battery, which would be a negligible quantity, we have—

$$C = \frac{\text{E.M.F.}}{r} = \frac{4}{20 + 20} = \frac{4}{40} = \cdot 1 \text{ ampere.}$$

If now the E.M.F. of the battery is doubled, the formula will work out thus—$C = \frac{8}{40} = \cdot 2$ ampere.

The current is thus doubled, and the effect on the magnet of C will be increased accordingly, so that if arrangements were made in listening at the telephone to switch on first 4 volts, and then by a single movement to increase the E.M.F. to 8 volts, without actually disconnecting, two distinct movements of the diaphragm would be heard. This illustration shows that by increasing or decreasing the current which passes round the receiver coil the diaphragm can be agitated exactly the same as if an actual disruption of the circuit took place.

A method of **increasing the current in the receiver** without increasing the battery power is the following. Assuming the same circuit as in fig. 706, we have a current of ·1 ampere in the circuit. Suppose the resistance coil *a* is now taken out without breaking the circuit. This is best accomplished by providing a switch D (fig. 707), which, when on 1, leaves *a* in

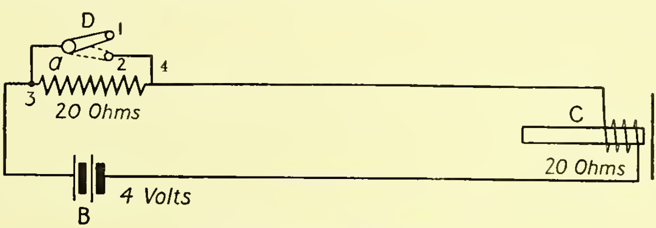


Fig. 707.—Resistance Coil and Switch

circuit, but, when on 2, short-circuits it so that all the current passes from the point 3 through the switch lever, as shown by broken lines, to the points 2 and 4, leaving the coil *a* without any current passing through it; it might, in fact, just as well be disconnected. With the switch in No. 2 position, therefore, the formula will be as follows:—

$$C = \frac{\text{E.M.F.}}{20} = \frac{4}{20} = \cdot 2 \text{ ampere.}$$

By halving the resistance of the circuit we have doubled the current, and every movement of the switch arm between the points 1 and 2 will result in the agitation of the receiver diaphragm.

These examples, in which the simplest possible figures are assumed, illustrate clearly the principle of the Hughes microphone, which is nothing more or less than an apparatus capable of varying its resistance under the influence of sound vibrations. Such an apparatus connected in the circuit of a telephone, in place of the coil *a* and switch D (fig. 707), would, in operation, cause variations in the quantity of current passing in the circuit, and correspondingly affect the magnet and diaphragm of the receiver.

The original Hughes microphone consisted of a carbon rod supported loosely by a carbon block at each end. The exact construction is shown sectionally in fig. 708. *a* is a thin pine board fixed to a base *d*, and carrying two carbon blocks *b* and *c*. Each of the latter is hollowed out at its centre,

and a carbon rod *e* is supported loosely in these hollows. When connected in circuit with a Bell receiver R and battery B, as shown, the slightest movement of the carbon rod *e* in the hollows of *b* and *c* is heard in the receiver, owing to the fact that such movement varies the degree of contact and, as a result, the resistance of the circuit. If the pine board *a* is made to vibrate by speaking against it, the carbon rod *e* will be subjected to a corresponding disturbance, and will cause variations in the resistance of the circuit exactly corresponding to the vibrations common to the words spoken.

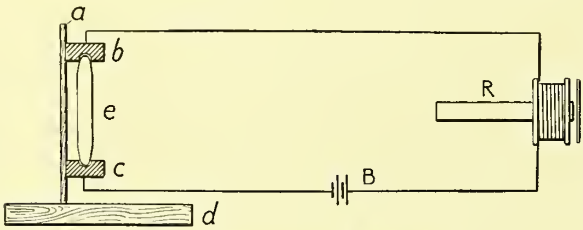


Fig. 708.—Original Hughes Microphone

As above demonstrated, any variation in an electrical circuit will vary the quantity of current passing. In the present case the variations are very rapid, and exactly synchronize with the sound waves projected against the pine board. As a result, the magnet of the receiver is affected, and this in turn sets up a vibration of the diaphragm corresponding to the frequency of the sound waves which originated the disturbance of the carbon rod *e* resting in the hollows of *b* and *c*, and any words spoken against the pine board *a* will be faithfully reproduced in the receiver R.

In order that a conversation may take place between two distant points, it is necessary to provide **a microphone and receiver** at each point, connected as in fig. 709. The variations in resistance caused by speaking into either

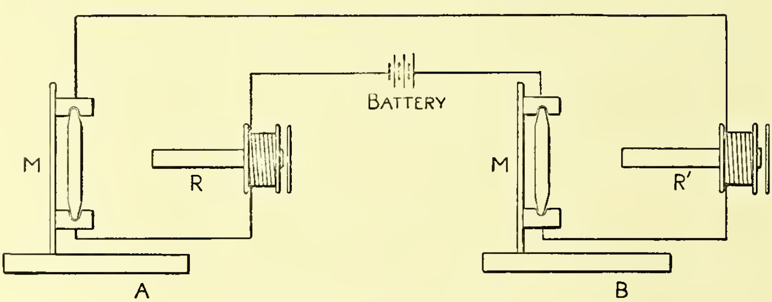


Fig. 709.—Microphone and Receiver

microphone will affect the whole circuit, so that a person at A speaking into the microphone M will be heard in the receiver R′ at B, and vice versa.

The invention of the Hughes microphone marked an epoch in the history of telephony, and so stimulated inventive genius that **great improvements** were rapidly made on the original form of apparatus. The principle having been once established, such improvements were comparatively easy, and consisted for the most part of designs for increasing the range of variations in the microphone contacts, in order that the current passing in the circuit should be subjected to greater changes. In many cases this was brought about by increasing the number of contacts, some

types of microphone being provided with as many as ten carbon rods, mounted loosely in carbon blocks on one pine board.

The Hunnings granular microphone is at present in universal use. Its principle is shown in fig. 710, in which *a* represents a carbon block or disc; *b* a similar disc or diaphragm, but much thinner than *a*. These are placed near each other, and the intervening space is filled loosely with granulated carbon *c*. The carbon granules, presenting a large number of contact points to *a* and *b*, are capable of causing very great variations in the resistance of the circuit, and correspondingly strong disturbances of the receiver diaphragm. This figure, however, gives simply the crudest idea of the Hunnings microphone at present in use. In practice a microphone constructed as in fig. 710 could not give lasting satisfaction, owing to the settling down or "packing" of the carbon granules. In other words, the natural tendency of the granules to gravitate downwards causes them to settle into a more or less solid mass, in which case their utility as microphonic contacts is practically destroyed. The endeavour of most inventors, therefore, has been to design a granular carbon microphone in which the packing of the carbon is reduced to a minimum. Some arrange their microphones so that they can be revolved, in order to loosen the granules after packing has taken place, whilst others shape the surface of the back block with corrugations or projections, on which the granules are partly supported and prevented from settling down.

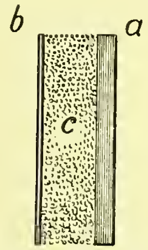


Fig. 710.—Diagram of the Original Hunnings Granular Microphone

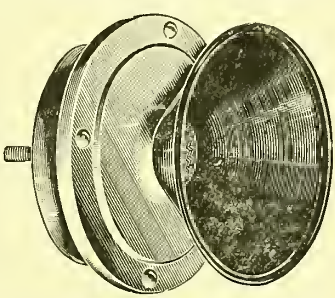


Fig. 711.—Simple Form of the Hunnings Granular Microphone

A simple form of Hunnings granular microphone is illustrated in fig. 711, from which it will be gathered that the microphonic contacts are enclosed in a case provided with a mouthpiece, by means of which the sound waves are directed against the diaphragm.

For descriptions of the various types of microphone the reader is referred to the more advanced text-books, in which more exhaustive details will be found.

Long-distance Telephony.—The arrangement of microphones and receivers shown in fig. 709 allows conversation to take place over short lines, but in the case of long lines the results are not so satisfactory, owing to the fact that a large "line" resistance minimizes to a great extent the effect of the variations caused by the disturbance of the microphone. This is due to the fact that the consequent variations of resistance are slight as compared with the resistance of the whole circuit. The following simple illustration, using imaginary figures, will serve to make this clear. Assume a microphone of 20 ohms resistance, a receiver of 20 ohms, and a line of 10 ohms, that is a total resistance of 50 ohms in the circuit. If the microphone increases in resistance by (say) 10 ohms, this represents a variation of 20 per cent, and the current passing will be decreased in proportion. If,

however, the line resistance is 200 ohms, the total will be 240 ohms. As the microphone is only capable of varying its resistance to the extent of 10 ohms, as before, the total resistance of the circuit is only varied to the extent of approximately 4 per cent. The current passing will, therefore, not vary in the same ratio as on short lines, and imperfect results will be obtained.

To overcome this difficulty **an induction coil** is used which is capable of amplifying the current variations and rendering telephony possible over long distances. The induction coil consists of an electro-magnet, on the core of which there are two windings of wire. The inner winding has a few turns of fairly stout wire, and is called the *primary coil.* The second winding consists of a large number of turns of fine wire wound over the primary coil, and called the *secondary coil.* The resistances of these

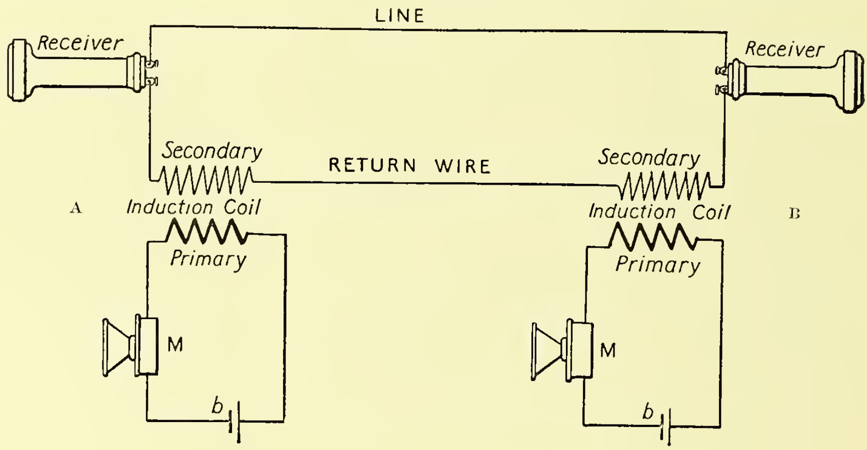


Fig. 712.—Two Telephones with Transmitters, Induction Coils, and Batteries

two windings in one type of induction coil used very largely are—primary, 1 ohm, and secondary, 25 ohms.

Fig. 712 shows the circuits of two telephones with transmitters, induction coils, and batteries connected as they would be for talking. The induction-coil windings are shown separated for clearness. The microphone M is connected in series with the battery *b* and the primary winding of the induction coil, and the receiver and secondary coil at A are connected by the line and return wires in series with the receiver and secondary at B, establishing a complete circuit. The current passing through the primary coil magnetizes the iron core, and the lines of force thus set up are projected across the turns of the secondary winding. On speaking into the microphone the current passing in the primary circuit is subjected to rapid variations, which cause a variation in the magnetism of the core and its magnetic field. These variations, by the law previously explained, cause varying currents of very high E.M.F. to be induced in the secondary coil which, passing through the receivers, produce the speech effects. By the use of such an arrangement of induction coils one or at most two Leclanché cells are sufficient for speaking over any reasonable distance.

CHAPTER IX

COMPLETE TELEPHONES

In the foregoing pages the relation of the transmitter and receiver to each other, and the arrangement of the electrical circuits, have been explained; but, in order to make the telephone of practical value, certain **accessory apparatus** are required. For example, it would be quite impracticable to leave the telephone permanently connected, as shown in figs. 709 and 712, as the batteries, being in continual use, would soon become exhausted, and the whole of the apparatus rendered useless. Some arrangement is therefore necessary to disconnect the battery when the telephone is not in use. This generally consists of a hook switch on which the receiver normally rests, and which, being movable, operates a contact device for disconnecting the battery.

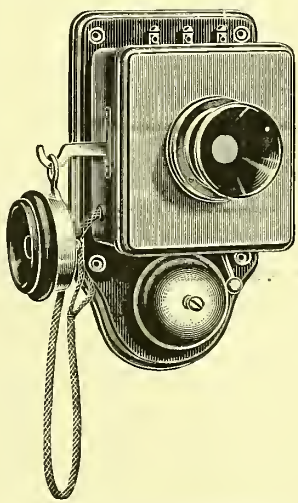


Fig. 713.—Direct-working Telephone

Further, it is obvious that some loud **signalling arrangement** is required for the purpose of intimating to the party at the distant station that his attention is required at the telephone. This involves the use of an electric bell and ringing key as a part of the telephone instrument. In order that the same wires may be used for signalling as for speaking, arrangements have to be made to disconnect the bell when speaking. This forms another function of the hook switch above referred to. For short lines, the call bell is of the ordinary electric-bell type, operated by a battery and push button. For long lines, a special ringing generator is used which operates a specially designed bell, which will be described in due course.

As sold commercially, telephones with their accessory apparatus may be divided into three groups as follows:—

(*a*) Direct-working telephones in which no induction coils are used, and which are generally used for short lines, such as are met with in private houses on electric-bell circuits.

(*b*) Induction-coil telephones with battery-calling arrangements, which can be used on lines up to (say) half a mile in length.

(*c*) Induction-coil telephones with magneto-calling arrangements, which can be used for practically any distance.

The direct-working telephone (fig. 713) includes in its construction a transmitter, receiver, automatic hook switch, ringing key, and call bell. At the top of the instrument there are three binding posts to which the wires have to be connected. As a rule, these terminals are stamped with the identifying letters L, BL, BT, signifying "line", "battery line", and "battery" respectively. Some makers, however, use the figures 1, 2, and

3 to represent the same terminals. An examination of fig. 714 will make the significance of this marking apparent. The circuits are here shown in detail. The two binding posts L, L′ are joined by one wire, and the two B L, B L′ are joined by another. A battery is provided at each end, having one pole connected to B T and the other to B L. It must be pointed out, however, that at No. 1 instrument the battery has the positive, whilst that at No. 2 has the negative pole connected to the B T binding post. In fig. 714 the circuits are shown as they would exist with the receivers hung on the switch hooks. K and K′ are the ringing keys, consisting of a spring contact *a*, a back contact *b*, against which *a* normally rests, and a forward contact *c*. H and H′ are the automatic hook switches, each consisting of a movable lever *f*, top contact *e*, and bottom contact *i*. When the receiver is hung on the hook, the lever *f* makes contact with *e*. When the receiver is lifted, the lever *f* is drawn by a spring into contact with *i*. If No. 1 wishes to speak to No. 2, he must first call No. 2's attention. This he does

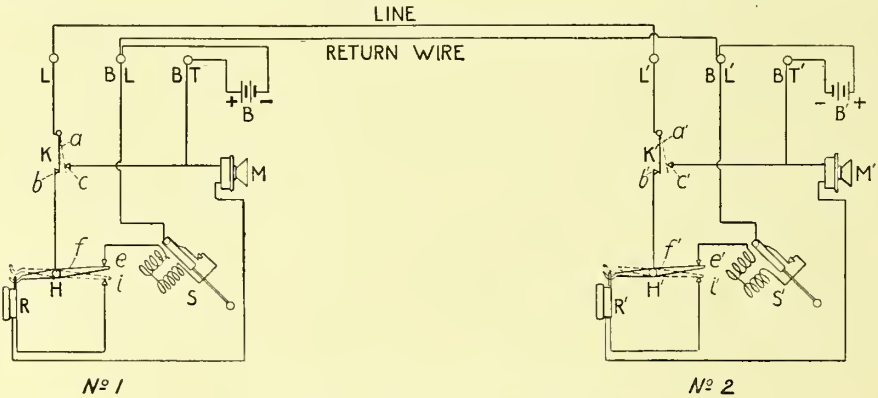


Fig. 714.—Circuits in Direct-working Telephone

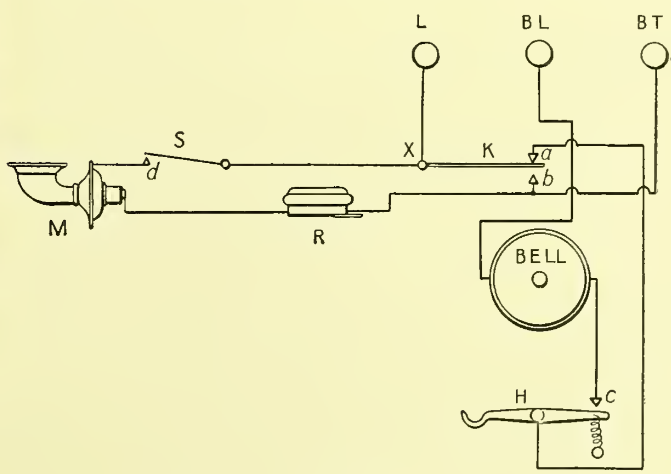
by pressing the push button of the ringing key. This causes *a* to break contact with *b* and to make contact with *c* (shown by the broken lines) as long as the pressure is maintained. The effect of this is to establish the following circuit: from the positive pole of battery B to B T binding post, contact *c* and spring *a* of ringing key, binding post L, line to binding post L′ at No. 2 station, spring *a*′ and contact *b*′ of ringing key, lever *f*′ of switch hook, contact *e*′, bell S′ to B L′, return wire to B L binding post at No. 1 station, and negative pole of battery B. The result is to cause No. 2 bell to ring as long as No. 1 keeps the ringing key depressed. Having sent the calling signal, No. 1 can either take his receiver and listen for the reply, or he can wait till No. 2 rings back. Assuming that both have their receivers off the hooks and held to the ear, a circuit is established as follows: commencing at positive pole of battery B, No. 1 station, to binding post B T, microphone M, receiver R, contact *i* of switch hook H, switch lever *f* (see broken lines), back contact *b* and spring *a* of ringing key, binding post L, line, binding post L′ at No 2, contacts *a*′ and *b*′ of ringing key, lever *f*′ of switch hook, contact *i*′ (see broken line), receiver R′, microphone M′, binding post B T′, negative pole of battery B′, positive pole of the same.

binding post B L′, return wire, binding post B L at No. 1, and negative of battery B.

If this circuit were drawn out divested of the accessory apparatus, it would be found to be substantially the same as that shown in fig. 709; consequently conversation can now proceed. The importance of connecting the battery the reverse way round at the two stations will now be apparent. If when the current reached the binding post B T′ it met the positive pole of B′, no current could pass, as the two batteries, being of equal power, would be in opposition to and neutralize each other.

A favourite type of complete telephone is that illustrated in fig. 715. In this the receiver and transmitter are combined in one piece, so arranged that, when the receiver is held to the ear, the transmitter comes in the correct position before the speaker's mouth. A switch key in the handle, which is kept depressed during conversation, performs the function of closing the speaking circuit, whilst an automatic switch hook disconnects the bell when the combination telephone is lifted.

No. 1



No. 2

Fig. 715.—Another Variety of Direct-working Telephone

No. 2 shows the internal connections of such an instrument: M represents the microphone, R the receiver, K the ringing key, H the automatic switch hook, and S the switch in the handle of the telephone.

When the telephone is on the hook H, as in No. 1, the hook makes contact with *c*. The line circuit is then as follows: terminal L to X, ringing key K, contact *a*, hook H, contact *c*, bell and terminal B L to return wire (see fig. 716). When the telephone is raised and the lever S pressed the circuit is

as follows: terminal L to X, lever S, contact *d*, microphone M, receiver R, and terminal BT to battery and return wire (see fig. 716).

Fig. 716 shows two instruments connected ready for use.

In some cases the bells on the telephone instrument may not be considered loud enough to call the attention of the person required. Under these circumstances it is usual to provide an instrument without a bell attached, but provided with a binding screw to which a bell of any size may be connected. No. 1, fig. 717 illustrates an instrument of this type, and No. 2 shows two instruments connected for talking, with the internal connections. The reader will doubtless be able to follow these connections with ease, as they are identical with those shown in fig. 714.

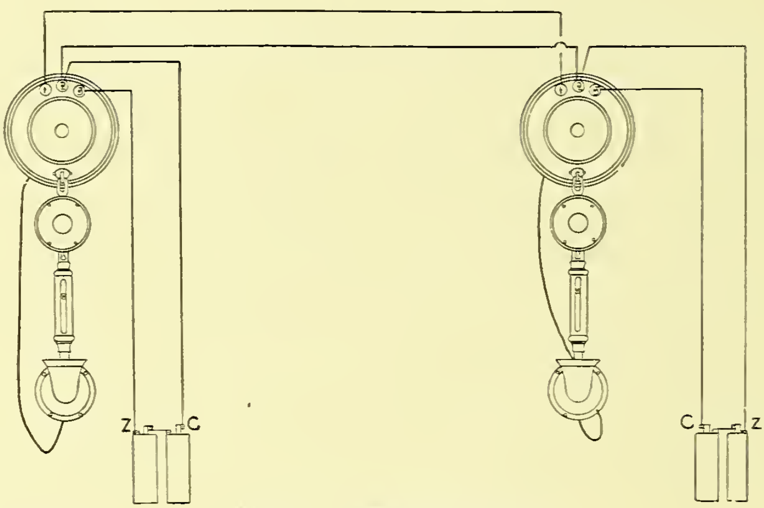
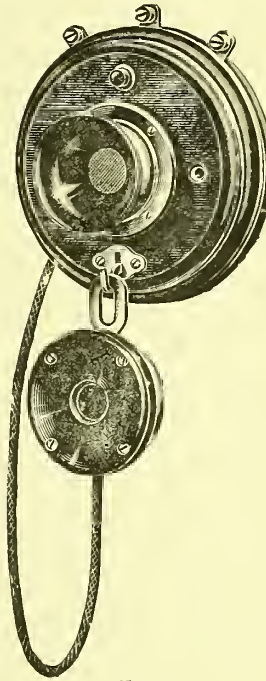


Fig. 716.—Two Telephones Connected

Telephones on Bell Circuits.—Direct-working telephones are particularly useful in private houses, hotels, &c., for attaching to the wires of electric-bell circuits. In this case the instrument for use in the rooms is not provided with a call bell, as it is only intended that the visitor or mistress of the house should call the servants, and not vice versa. The transmitter and receiver are combined in a similar manner to that shown in fig. 715, No. 2. There are, however, two switch keys in the handle, one of which must be depressed for ringing and the other for speaking. The flexible conductor terminates in a small ebonite block, provided with two metal pins, one conductor being connected to each. An electric-bell push, similar to the ordinary types, but fitted with two small sockets in its edge, is provided. These sockets are connected to the push springs. They are spaced the correct distance from each other, to allow the two pins of the plug referred to to be inserted, thus making connection between the push springs and the telephone. A hook fixed on the under side of the push serves to support the telephone when not being used for speaking. No. 1, fig. 718, illustrates a telephone of this type, and No. 2 shows the connection of the various parts in relation to each other. Tracing the circuit from

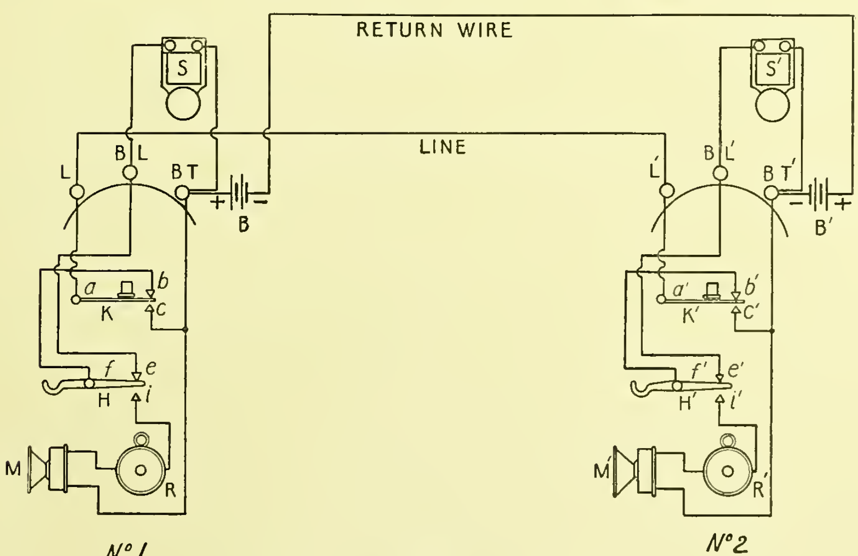
pin 1 of the plug P, the flexible conductor passes to the key K, but beyond this there is no path, unless one of the levers is pressed down. Assuming, therefore, that the ringing key C is depressed until it makes contact with *a*, the circuit will then pass to the second conductor and to pin 2 of the plug P, thus closing the circuit with the same effect as an ordinary electric-bell push. When the speaking key S is depressed, the circuit from pin 1 passes to the lever S, contact *b*, microphone M, receiver R, and through the flexible conductor to pin 2; thus, as long as the lever is depressed, the telephone is in circuit on the bell wires. The utility of the plug arrangement is to allow the telephone to be moved from room to room.



No. 1

It is, of course, essential that all rooms which require telephonic communication with the servants should be fitted with the **specially constructed pushes.** For the bedrooms, a pear push (fig. 719) can be used, and the telephone can be hung on the bedstead rail or any other suitable form of support.

At the receiving end—that is, the end which receives the call—a slight alteration of the wires



No. 2

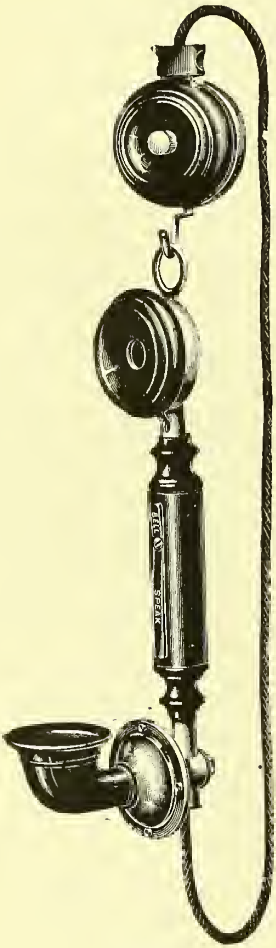
Fig. 717.—Telephones with Separate Bells

is necessary. The instrument shown in fig. 717 is used. Fig. 720 shows the connection of two telephones to an existing electric-bell circuit.

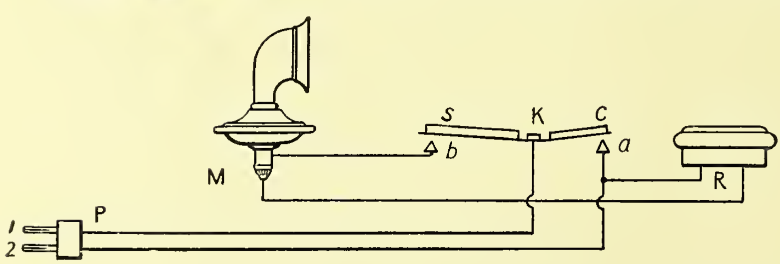
These circuits can be readily traced, and it would be superfluous to detail them.

In the case of a bell system in which **an indicator** is used to receive calls from a number of rooms, the connections must be arranged as in fig. 721. The operation is exactly the same as in fig. 720. The talking takes place through the indicator movement. Only the telephone in use is in circuit. If a person A in one room is talking, and another B lifts his telephone to call also, B will be able to overhear A's conversation. This, however, does not constitute a serious defect, as in private houses the chances are very great against such a contingency, and, even if it did happen, it is not likely to cause any trouble, as conversations of a private nature on such a system are very improbable.

Telephones to Call Both Ways.—In the above-described methods of connecting telephones to existing electric bells, it is, as stated, only possible to call one way, that is, from the rooms to the receiving point. It is, however, sometimes required that the attendants shall call to the rooms, and in such cases it is necessary to run an extra wire round to all the rooms. At the indicator end a special plug switch and an additional battery must be provided. No. 1, fig. 722, illustrates the plug switch referred to, and No. 2 shows the details of one of the plug connections viewed from the back; *i*, *l* are two springs, the latter carrying a metal pin *b*, which projects through a hole in *i* of larger diameter than *b*. The two springs rest in contact with each other at *d* and *c*. The pin *b* rests in



No. 1



No. 2

Fig. 718.—Telephone for Electric-bell Circuit

such a position that it projects partly over the hole of the socket *e*; consequently when the plug P is inserted in *e*, it makes contact with *b*, pressing it on one side, and causing the spring *l* to break contact with *i* at *c* and *d*.

It will be readily understood that if *l* is connected to the line, *i* to the indicator, and the plug P to the telephone, the telephone can be connected to *l* by inserting the plug in *e*, while by the same action the indicator is disconnected therefrom.

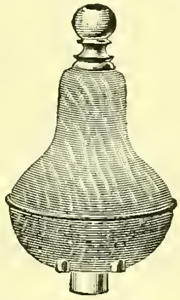


Fig. 719.—Pear Push for Telephone

Fig. 723 illustrates a complete system using the plug switch described with fig. 717 instrument at the indicator and fig. 713 instrument in the rooms. Instrument fig. 715 can be used if the terminals are connected to the lines, as shown in this diagram. At 1, 2, 3 are shown three telephone instruments, which may be of the same pattern as fig. 715. These ring to the indicator on the movements A, B, and C respectively. The instrument at the indicator end of the fig. 717 type requires altering slightly to meet these particular requirements. This alteration consists in removing the speaking side of the circuit, which is ordinarily connected to the BT terminal, and connecting it to the BL terminal. In the diagram this alteration is shown, the broken line indicating the original position of the connection *x*. The battery A is used for ringing inwards and for speaking. The battery B is used for ringing outwards only. If No. 1 wishes to speak to the central point, he presses the ringing key *k*, which establishes the ringing circuit

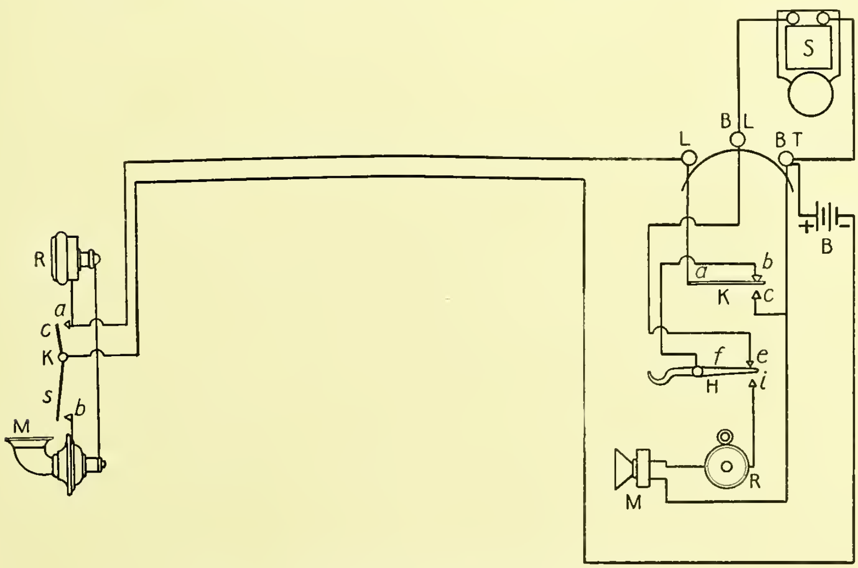


Fig. 720.—Two Telephones connected on Electric-bell Circuit

as follows: + of battery A, terminal BT, contact *c*, key *k*, terminal L to line, terminal *l* of plug switch, contacts *f* and *a*, terminal *i* to indicator A, through same to bell and − side of battery A. If the central wishes to call No. 1, he does so by inserting the plug P in *e*, and pressing his ringing key *k'*. This closes the following ringing circuit: + of battery B to contact *c'* of *k'*, L terminal and plug P to *e*, where it makes contact with *b*

(at the same time breaking contact between *f* and *a*), terminal *l*, line to terminal L of the telephone, ringing key *k*, switch hook H, bell of No. 1 instrument, B L terminal to extra wire, and so back to − of battery B.

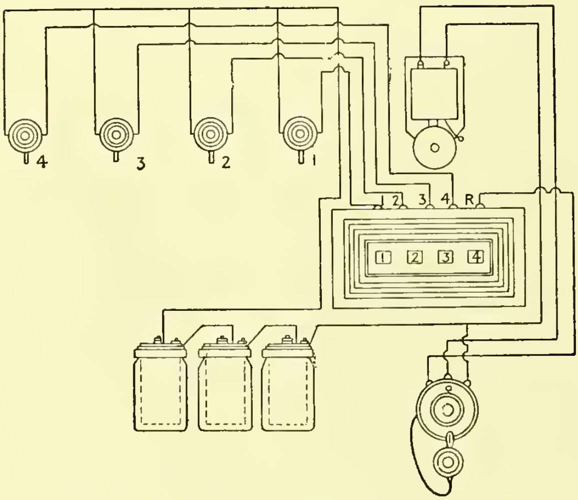
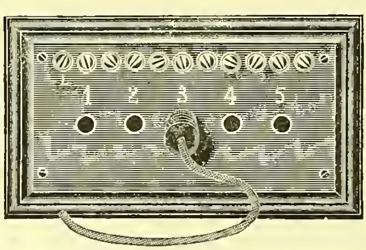


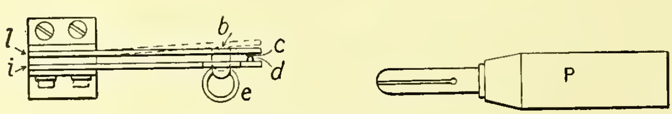
Fig. 721.—Connections for Telephone on Electric-bell Circuit with Indicator

The ringing up having been successfully accomplished, each now lifts his telephone, establishing the following speaking circuit: + of battery A to BT terminal at No. 1, receiver R, microphone M, automatic switch hook H, terminal L, line to *l* of plug switch, plug P (which has been inserted in the socket at *e*), terminal L of central telephone, switch hook H′, microphone M′, receiver R′, terminal B L, and − of battery A. They can now converse. The position assumed by the automatic switches when talking is shown by broken lines.

Telephones with Battery-calling Arrangements and Induction Coils.—The automatic switch hook of this class of telephone must be of a slightly more elaborate construction than in direct-working telephones, by reason of the fact that, in addition to alternately connecting and disconnecting the bell and telephone, it has also to open and close alternately the local primary circuit. For this purpose a second contact spring is arranged to make contact with the switch hook when the telephone is raised. There is



No. 1



No. 2

Fig. 722.—Plug Switch and Connections

also an additional binding post provided—making four in all—lettered as follows: L, M C, C, and Z E, denoting respectively "line", "microphone carbon", "carbon", and "zinc earth". The significance of these markings will be apparent on examination of fig. 724, which shows the internal connections of two induction-coil telephones connected for actual use.

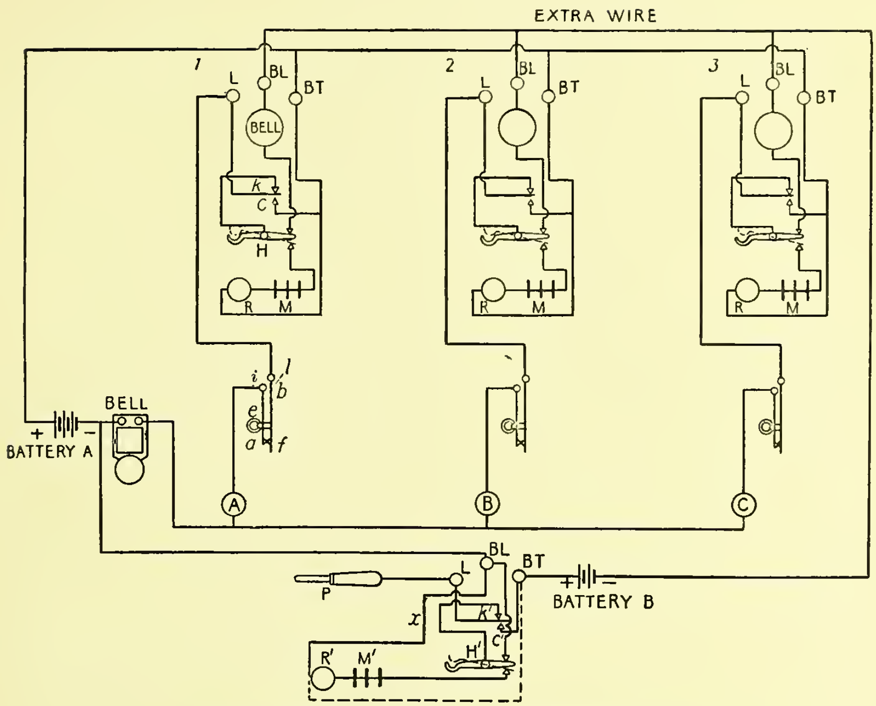


Fig. 723.—Telephones calling both ways on Electric-bell Circuit

The connecting posts are denoted by the above markings, and I, I′ are the induction coils. If A wishes to call B the cycle of operations is as follows.

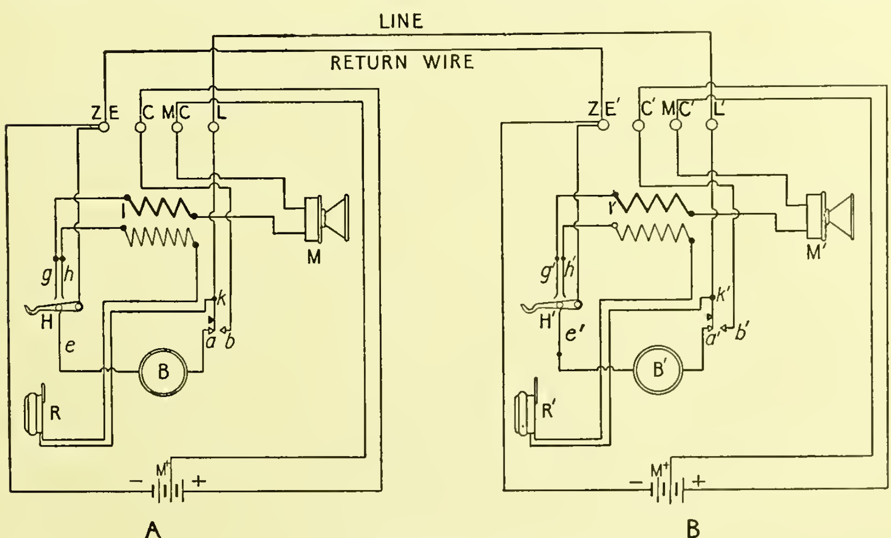


Fig. 724.—Telephones with Induction Coils

The ringing key *k* is pressed into contact with *b*, when the current passes from positive of battery to stud *b*, key *k*, line terminal L, line to ter-

minal L′ of B's instrument, key *k′*, contact *a′*, bell B′, contact spring *e′*, switch hook H′, terminal ZE′, return wire and back to − of battery at station A. This rings the bell at B, who replies by pressing his ringing key. Both parties then remove their receivers from the switch hooks, and the following circuits are established: terminal L at A to line,

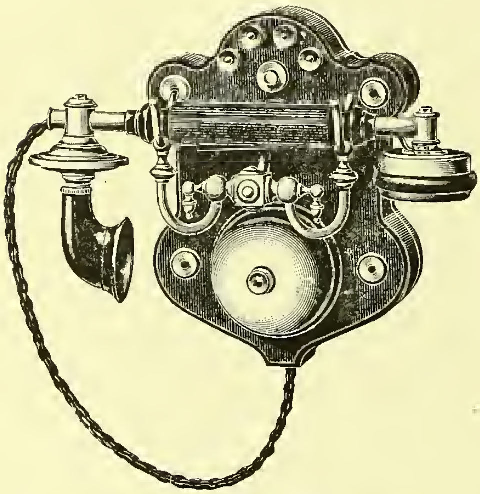


Fig. 725.—Induction-coil Battery-call Telephone with Switch Lever in Handle

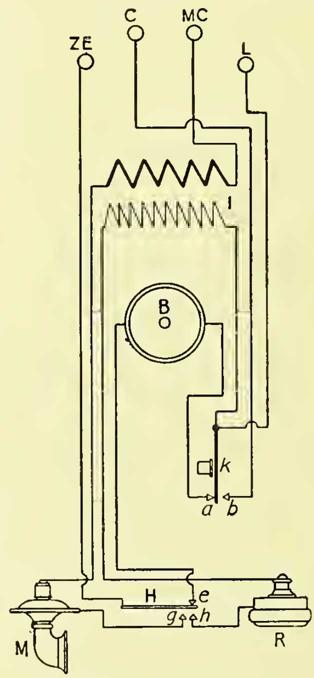


Fig. 726.—Diagram of Connections in Telephone shown in Fig. 725

terminal L′ at B, ringing key *k′*, receiver R′, secondary of induction coil I′, contact spring *h′*, hook H′, and terminal ZE′ to the return wire and terminal ZE, hook H, contact spring *h*, secondary of induction coil I, receiver R, key *k*, and back to terminal L of A's instrument. The local primary circuits in each case run as follows: M + of battery, terminal MC, microphone M, primary of induction coil I, contact spring *g*, hook H, terminal ZE and, − of battery.

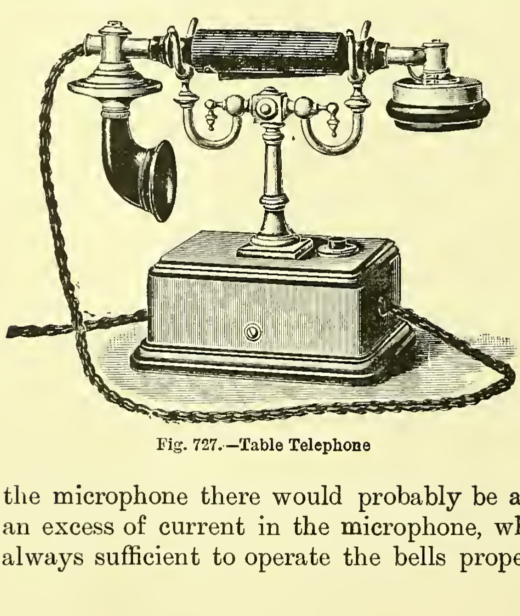


Fig. 727.—Table Telephone

It will be observed that in the case shown the battery consists of three cells, all of which are used for ringing, but only two are used for speaking. This arrangement is necessary, because if more than two cells were used on the microphone there would probably be a hissing or boiling noise due to an excess of current in the microphone, whilst two cells are by no means always sufficient to operate the bells properly. The method shown allows

any number of cells to be used for calling whilst retaining only the desired number for the microphone.

Fig. 725 illustrates an induction-coil battery-call telephone in which the automatic switch hook is dispensed with. **A switch lever** is fitted in the handle of the hand combination, which fulfils the same function as the automatic switch hook of the instrument shown in fig. 724. Fig. 726 shows diagrammatically the connections of such an instrument. The parts are lettered in the same manner as the corresponding parts of fig. 724, so that it is unnecessary to recapitulate the circuits.

Fig. 727 illustrates **a table instrument** of a similar type. In this the terminals L, Z E, M C, and C are connected through a flexible conductor to a wall rosette similarly marked. This is fixed to the wall or skirting near which the instrument is placed, and the line and battery wires are connected thereto.

CHAPTER X

INTERCOMMUNICATION TELEPHONES

In connection with private telephone installations in business houses, no system has come into such universal use as **the intercommunication system.** This provides for connecting up any number of departments (within certain limits) in such a manner that anyone can call and speak to any other

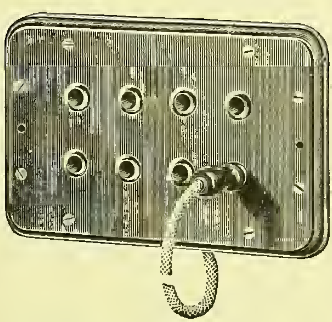


Fig. 728.—Intercommunication Switch with Plug Line Selector

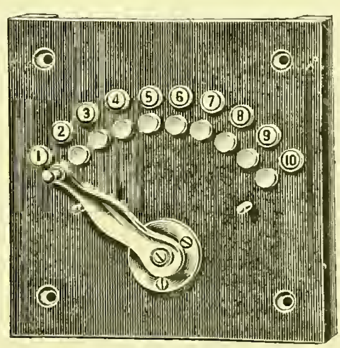


Fig. 729.—Intercommunication Switch with Lever Line Selector

without the assistance of a third person. This involves the use of line-selecting devices in conjunction with the instruments, and also a special system of wiring.

The original method of arranging intercommunication telephones was to provide a **plug or lever line selector**, as shown in figs. 728 and 729 respectively, connected as shown in fig. 730. The last shows a system of five stations. It will be seen that there are six wires run throughout the system, and that at certain points other wires are tapped off them and led to the various instruments. The six wires are one for each station and a

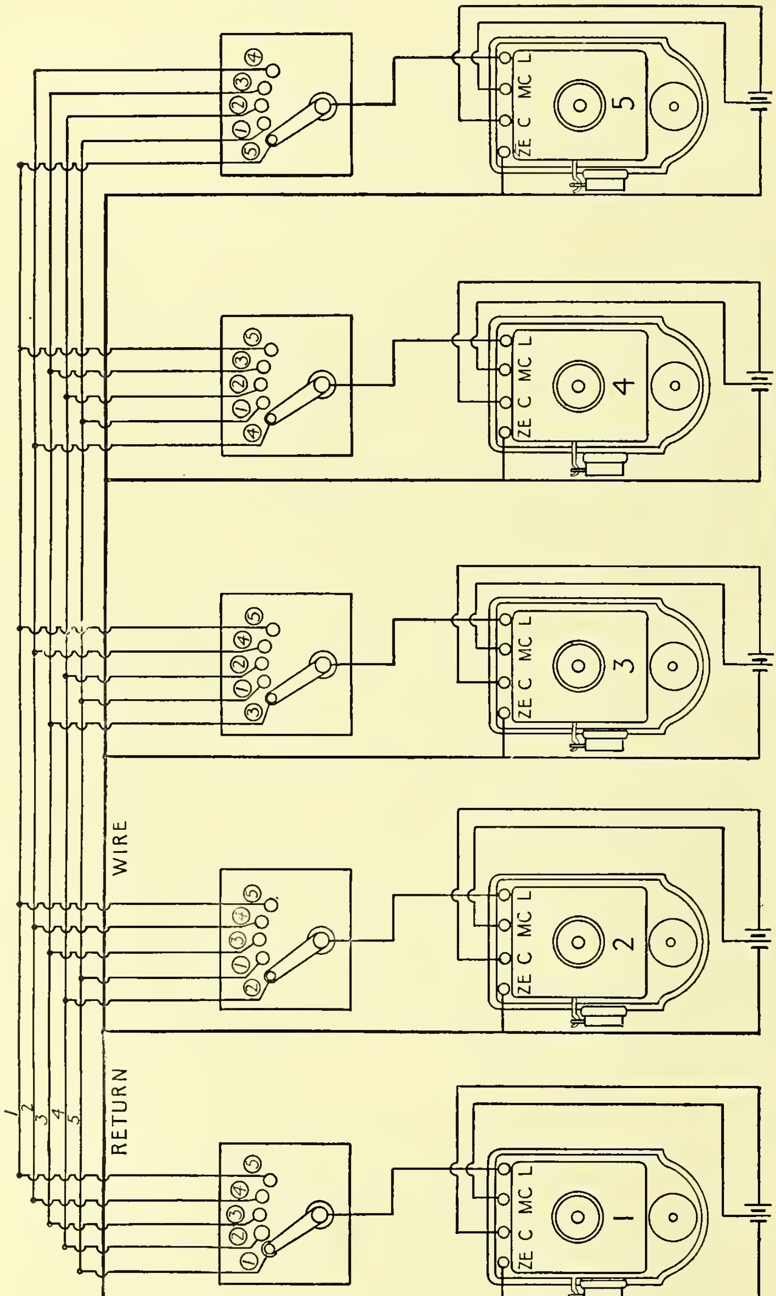


Fig. 730.—Connections for Intercommunication System with Five Stations

common return wire. Special attention is called to the method of arranging the wires on the switches. They are not all connected in rotation, as might be supposed would be the case. No. 1 has the wires connected in regular consecutive order, but No. 2 reads 2, 1, 3, 4, and 5; No. 3 reads 3, 1,

2, 4, and 5; No. 4 reads 4, 1, 2, 3, and 5; and No. 5 reads 5, 1, 2, 3, and 4. With this arrangement the line of any particular station is the left-hand stud of the switch at that station. This is called *the home line.* Under normal conditions all the switch arms should be resting on the home-line stud, otherwise it would be impossible for them to be called up. The lever of the switch is connected to the line terminal of the telephone instrument. If a person at (say) No. 2 station wishes to call No. 5, he does this by turning his switch lever to No. 5 and pressing his ringing key. This sends a current via the No. 5 wire to the home-line stud of No. 5 switch, through No. 5's switch lever to the line terminal, and through the bell to the return wire, whence it returns to zinc of battery at No. 2. On receiving the call, No. 5 simply lifts his telephone in reply, and the conversation can then take place. When the conversation is finished, the switch lever at No. 2 must be returned to the home-line stud. This system answers very well if the users do not forget to replace the switch lever. In practice, however, they often do forget, and consequently much confusion of cross ringing results.

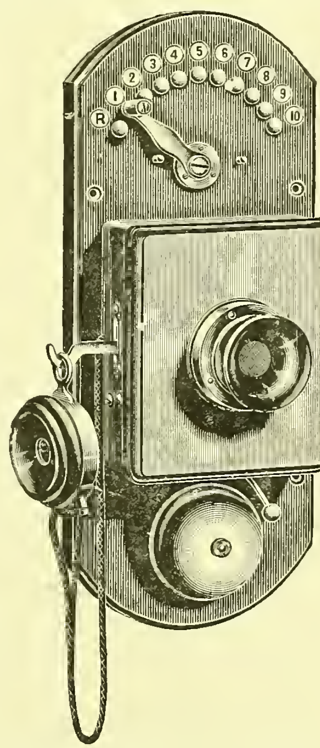


Fig. 731.—Improved Wall-pattern Telephone for Intercommunication System

To obviate this difficulty, the selector has been combined with the instrument, and a **special arrangement of connections** devised, so that the switch can be left in any position without interfering with the receiving of calls. Fig. 731 illustrates a wall-pattern telephone constructed on this principle, and the internal connections are shown in fig. 732. An examination of this diagram will show that the call bell is always connected to the home-line stud of the selector, and that the selector lever controls the secondary circuit only. In the event of a call being received, the current from the calling station enters the home line terminal of the instrument and passes through the bell via the switch hook to the return wire, and this circuit is always open (provided that the receiver is on the hook) irrespective of the position of the selector lever. When, however, a call is received, the receiver must then be returned to the home-line stud before the call can be answered. Fig. 733 shows five stations connected for use. In this method, instead of using several cells at each station for ringing and speaking, a single cell for speaking only is used. The ringing is accomplished by a single set of three or more cells. This necessitates running an extra wire, thus making the total number of wires necessary two more than the actual number of stations. This method, which is generally adopted, effects a considerable economy in batteries and maintenance. In order to simplify the wiring of the system, the line selector is provided with an

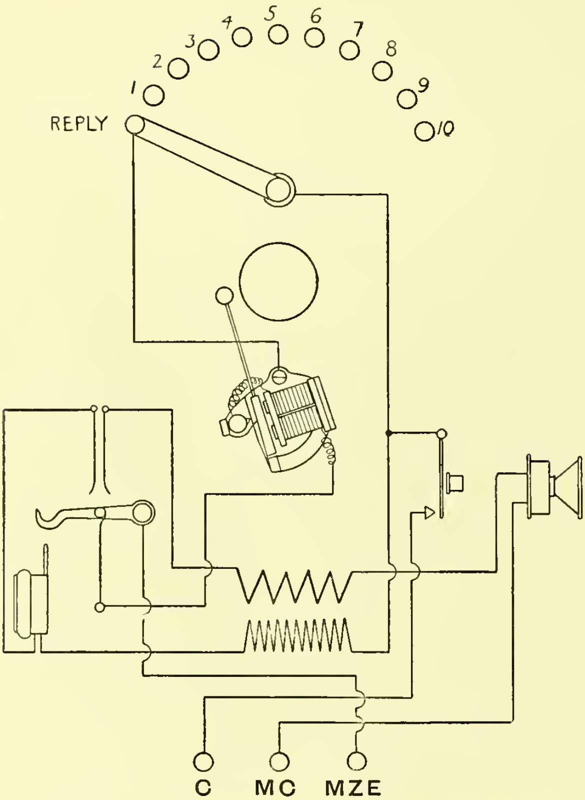


Fig. 732.—Internal Connections of Telephone shown in Fig. 731

extra contact stud; thus on a ten-station instrument there are eleven studs, namely, home line, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. The home-line stud is usually lettered "Reply", or "R", indicating that, as above stated, the selector lever must rest on that stud when replying to a call. By adopting this method the actual connections to the instruments are much simplified.

Omitting the home-line connection for the time, the line wires are connected to each instrument in exactly the same way; thus, the wire which is connected to No. 1 stud in one case is connected to No. 1 throughout the system. Having connected all the instruments, the fitter must proceed to No. 1 station and connect the reply terminal to No. 1; then he must go to No. 2 station and connect the reply to No. 2

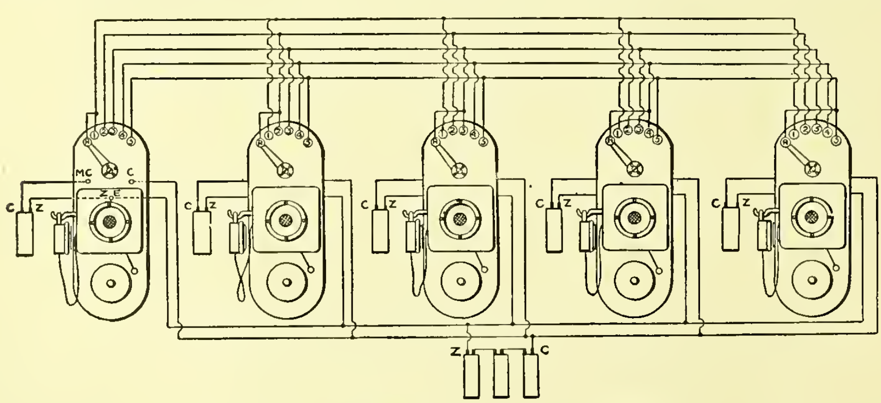


Fig. 733.—Intercommunication Telephone for Five Stations

terminal, and so on throughout the system. This is equivalent to connecting the home line direct to the reply stud in every case.

A considerable amount of labour is saved by using wires made up in

the form of **multiple cables**, that is, with the necessary number of lines, each separately insulated, and then made up together under one covering. The individual coverings of the conductors are all of different colours, thus facilitating the identification of any one line. These cables are usually stocked by suppliers, with a standard number of conductors corresponding to the standard number of stations for which the stock instruments are arranged. Usually the instruments start with five stations, and advance by fives up to thirty, beyond which intercommunication telephones are not considered practicable. The actual number of wires in the cables are two more than the number of telephones; thus, if there are ten stations, the cable will have twelve conductors—namely, ten lines, one zinc earth (common return), and one carbon wire, the last being the feed to all the instruments from the ringing battery. When a table-pattern intercommunication telephone is used, the connections are led from the instrument through a multiple flexible cable, which terminates on the terminals of a wall rosette, to which the lines are connected.

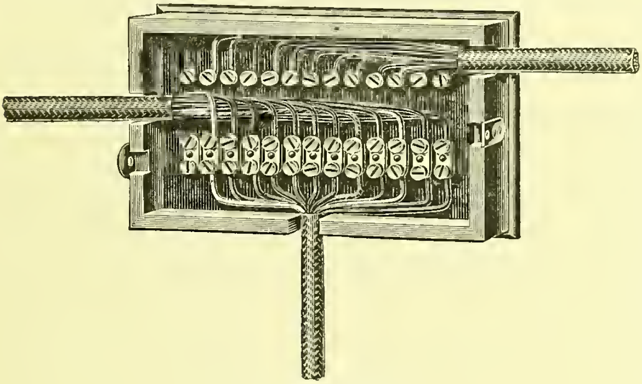


Fig. 734.—Junction Box

To facilitate making the tee joints to the cables, a **range of junction boxes** is made (fig. 734), containing three rows of terminals, which are joined together in groups of three at the back of the box, as shown in the end sectional view in fig. 735. Thus all the No. 1 terminals are joined together, all the No. 2, and so on. In use the cable off which the tee is to be taken is cut, and one of the free ends is joined to the top row of screws and the other end to the middle row. When the cable to be joined has had its conductors connected to the bottom row of terminals, the tee joint is complete (see fig. 734). By this means a perfectly reliable joint is made, and one which will admit of examination and alteration to the connections whenever desirable.

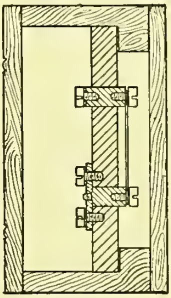


Fig. 735.—End Sectional View of Range of Junction Boxes

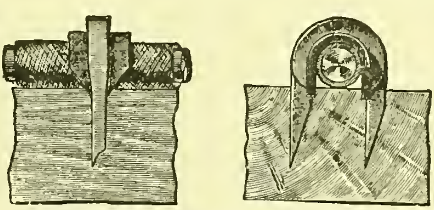


Fig. 736.—Insulating Staple

Casing and Staples.—The cables may be run in wood casing, or, if desired, can be stapled direct into position. In the latter case, however, a special form of insulating staple should be used. This staple is constructed with a vulcanized fibre lining under the arch, as shown in fig. 736, which prevents the possibility of injury to the cable.

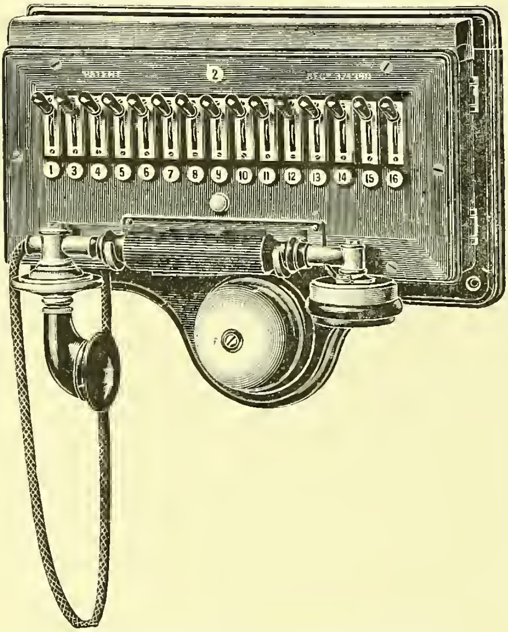


Fig. 737.—Automatic Intercommunication System

Automatic Intercommunication Telephones. — The intercommunication system above described was a considerable advance on the older method, but notwithstanding the fact that a call could always be received irrespective of the position of the line selector, there still remained the drawback that when a call was received it was necessary to return the lever to the reply stud before a reply could be given. The next development of this system, therefore, came in the form of a line selector which, after a conversation was finished, would be automatically restored, thus entirely relieving the operator of any effort of memory whatever. One of the most successful of these is shown in fig. 737. The line selector consists of a number of small levers projecting through the front of the case. Each of these is arranged on a separate cam inside the case. When any lever is pulled down, the cam is moved round until it engages in a long pivoted bar, common to the whole of the levers. In this position the selecting lever is locked in contact with the required line. The calling up is done by pressing a ringing key in the usual manner. The hooks on which the hand combination normally rests are movable, and are arranged in such a manner that, when the hand

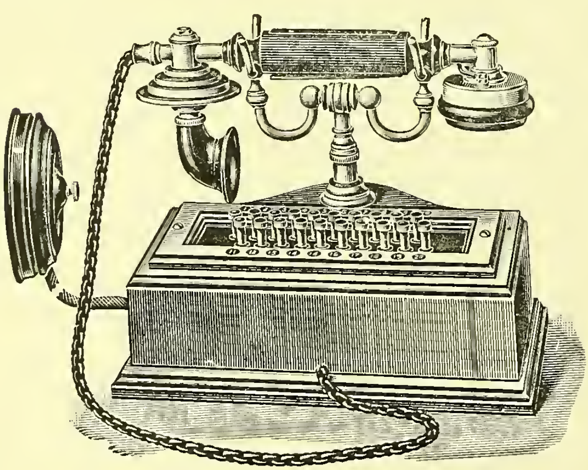


Fig. 738.—Automatic Replacement Telephone (Table Pattern)

combination is replaced, the movement inside the instrument lifts the pivoted bar and throws it out of engagement with the selecting lever, which is free to regain its normal position. Table-pattern instruments of this class are also made.

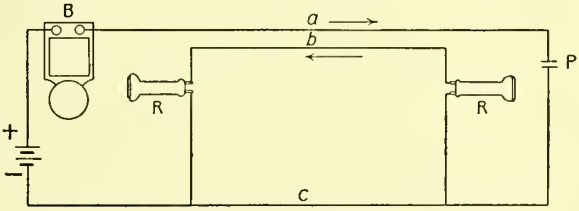


Fig. 739.—Diagram illustrating the Phenomena of Induction

Fig. 738 illustrates another type of automatic replacement telephone of the table pattern. The same mechanism is also adopted for wall telephones. The selecting is accomplished by pressing any one of a series of push buttons. Although the internal mechanism differs from the above, the principle adopted is much the same, in that replacing the hand combination causes the push button, which has been in operation, to regain the normal position.

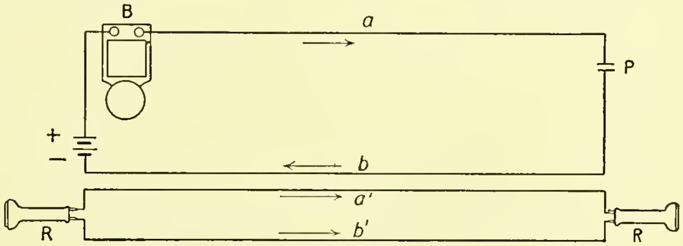


Fig. 740.—Telephone Circuit with Separate Line and Return Wires

The intercommunication systems described all possess a defect which has taxed the ingenuity of inventors to a considerable degree to overcome. This defect is that of cross-talk, or overhearing of conversations by a third party. This can take place in two ways. Firstly, if No. 1 has called up No. 4 and is talking, then, if any other number calls up No. 4, it follows that on lifting his receiver he is in direct tap on the line which is engaged, and will hear the conversation. Secondly, conversation may be overheard even when the parties listening are not connected directly to the line of the parties who may be talking. For instance, if Nos 1 and 4 are talking and No. 2 calls No. 3, then either couple can overhear the other couple's conversation. This is due to induction between the lines, and, although the overhearing is not such as to prevent the use of the telephones for ordinary interdepartmental communications, it is sometimes considered objectionable that the conversation of principals should be overheard by subordinates.

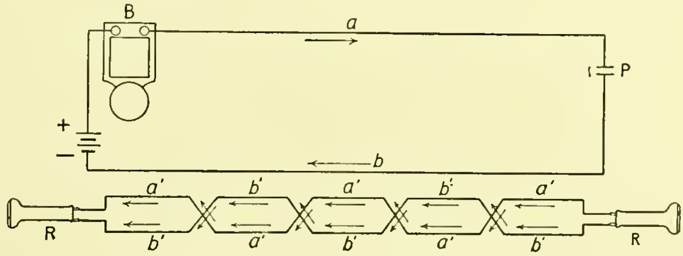


Fig. 741.—Telephone Circuit with Twisted Line and Return Wires

Without attempting to deal with **the phenomena of induction** in all its

phases, an illustration of its nature will assist in obtaining a comprehension of the means adopted for combating it. An electrical conductor carrying a current is always surrounded by a magnetic field. If the current is intermittent, alternating or undulatory, then the field is continually subjected to changes, which changes will induce currents in any conductor lying within the area of its influence. Thus, suppose that, in fig. 739, *a* is a conductor connected in circuit with a bell B, battery + and −, and push P, and that *b* is a telephone line using the same return wire. If the push is pressed, a current will pass along *a*, which will be rapidly interrupted by the electric bell. Owing to the rapid disruption of the magnetic field surrounding *a*, currents will be induced in *b*, and corresponding sounds can be distinctly heard in the telephone receiver. The induced currents will have an opposite direction to the disturbing currents, as shown by the arrow heads. To overcome this, the arrangement shown in fig. 740 was devised—that is, separate line and return wires are provided for the telephone. The induced effects now take place in the *two* conductors *a′*, *b′*, each having the same direction; it is assumed that the induced effects in one line *a′* will

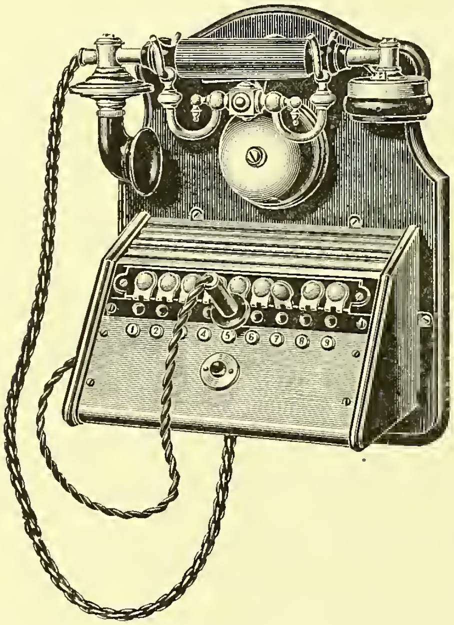


Fig. 742.—Intercommunication Telephone to Prevent Overhearing

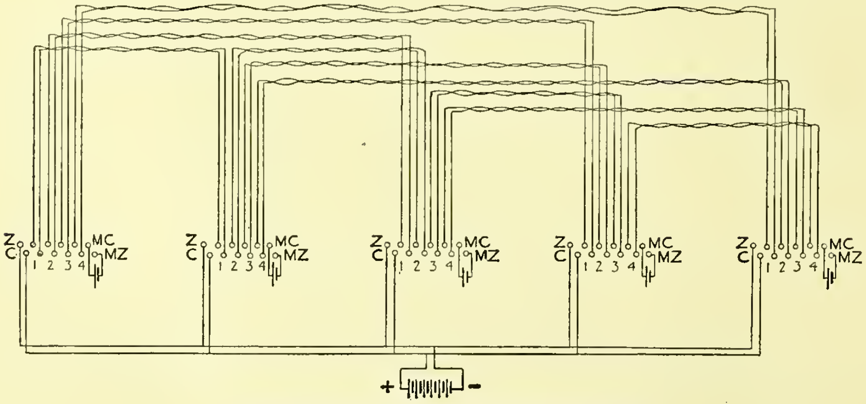


Fig. 743.—Method of Wiring to Prevent Overhearing

neutralize those in the other *b′*. In practice, however, this does not happen entirely as expected, owing to the fact that one line is nearer than the other to the source of disturbance. The induced current in *b′*, therefore, is

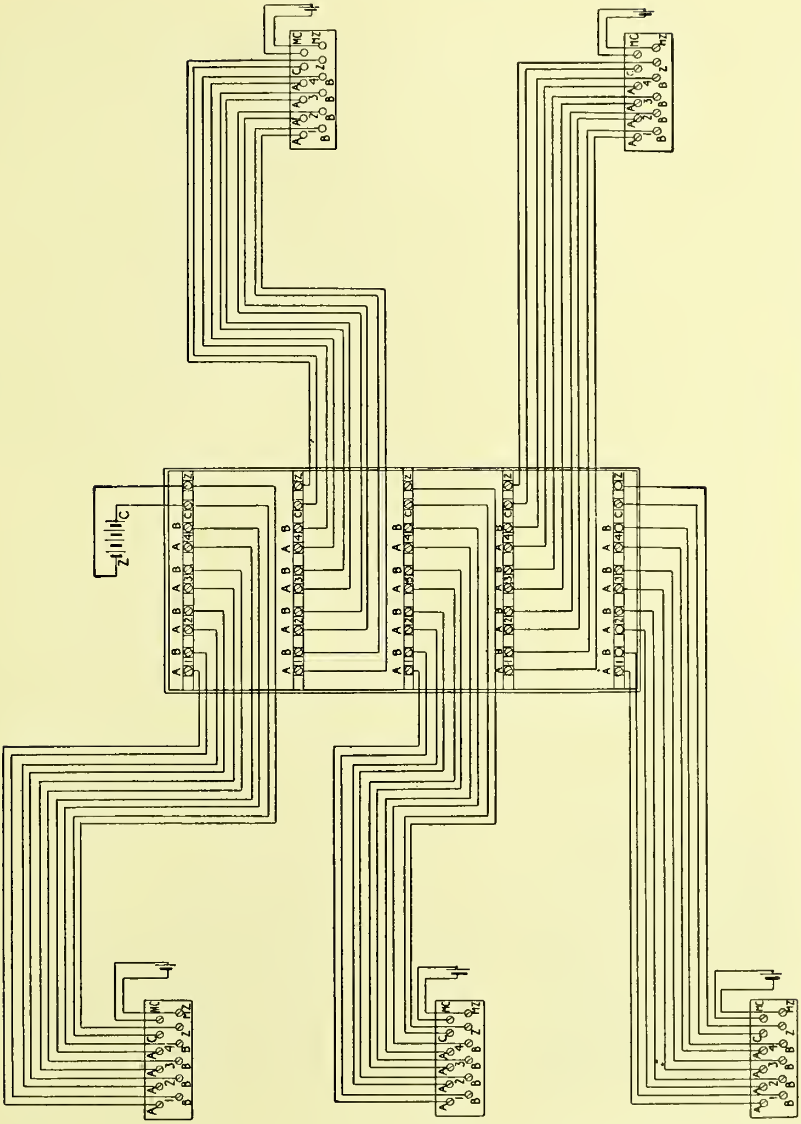


Fig. 742.—Connections for Intercommunication Telephone

weaker than that in a', and the net result in the telephone is equal to the difference in the effect on the two conductors a' and b'. This is, however, entirely overcome by twisting or transposing the wires a' and b' as shown in fig. 741. Here it will be seen that the two wires a' and b' have equal surfaces exposed to the disturbing line; consequently the strength of the induced current is equal in each, resulting in a perfect neutralization of the induced effects.

From a study of this phenomenon it would appear that the simple remedy for cross-talk on telephone intercommunication sets would be to run a line and return (or *double lines* as they are usually termed) to each, in place of that shown in fig. 733. This would not, however, prevent the

tapping of the line by a third party selecting one of the lines engaged. To overcome this difficulty several arrangements have been devised, one of the most successful perhaps being that illustrated in fig. 742. This system is necessarily more expensive in wiring than ordinary systems, as in addition to the extra cost of the telephone it requires that a twisted twin wire shall run from each instrument to every other on the system, as shown in fig. 743. The simplest arrangement of wiring is to use cables containing the necessary number of twisted twin wires, and run from each instrument to a central point where they terminate on a common distribution board. Fig. 744 shows a diagram of the connections on such a method. The numbers placed against the terminals on the distribution board make the operation of connecting extremely simple. The terminals are connected to each other at the back of the board in such a manner that, when the cables are connected to the terminals in the order marked, they follow as a matter of course.

CHAPTER XI

MAGNETO-CALL TELEPHONES

For **long-distance telephony** the ordinary method of calling by means of a battery and electric bell is superseded by the use of a magneto-generator and polarized bell.

The magneto-generator is constructed with three or more horse-shoe magnets clamped together and arranged with a shuttle-shaped iron armature, on which fine wire is wound in a large number of turns, and which is

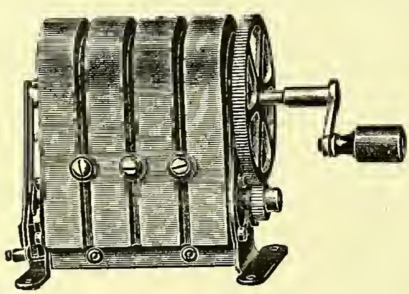


Fig. 745.—Magneto-generator with Four Magnets

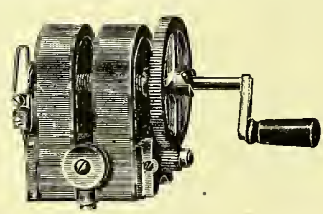


Fig. 746.—Magneto-generator with Two Magnets

pivoted at each end so that it lies directly in the field of the magnet between its pole pieces. A suitable gearing is arranged, so that, by turning a handle, the armature is caused to revolve rapidly in the magnetic field, this movement giving rise to alternating currents of high E.M.F. induced in the armature winding. These currents are collected from the armature by means of suitable contact springs. Fig. 745 shows a generator of this description with four magnets, such as is used in ordinary long-distance telephony. Fig. 746 shows a magneto-generator with two magnets, which is a type used when the calling is only required to take place over lines not exceeding 3 or 4 miles.

The polarized bell (or **magneto-bell**) is so called because its cores and delicately pivoted armature are polarized by allowing them to rest in the field of a powerful magnet. To make its operation clear, reference must be made to fig. 747. *a a* are the coils of an electro-magnet wound on the iron cores *s*, *s′*, joined by the iron yoke *b*; N S is a powerful permanent magnet fixed to the centre of the yoke *b*, and carrying at its north end a brass bracket *c*, from which the armature *n′n* is suspended on pointed pivots, and carries the hammer stem and knob. By this arrangement the two ends of the armature become polarized with a north polarity, whilst the two ends of the cores become polarized with a south polarity. If a current is now passed through the wire in the proper direction, the core *s* will become polarized with north polarity whilst *s′* will remain south. The result is a repulsion between *n* and *s*, and an equal attraction between *n′* and *s′*, causing the hammer to be thrown against the gong *g′*. If the current is reversed the reverse action takes place, and *s′* becomes north, whilst *s* remains south. The repelling and attractive influence of the armature is now opposite to the first. There is a strong repulsion between *n′* and *s′* and a strong attraction between *n* and *s*. The hammer knob is now thrown over against the gong *g*.

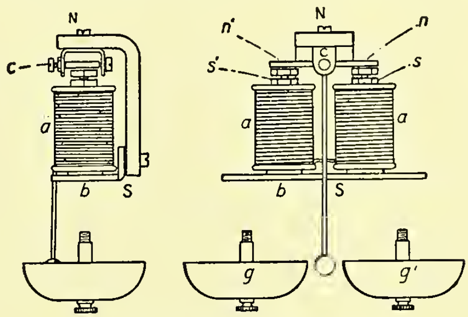


Fig. 747.—Polarized or Magneto-bell

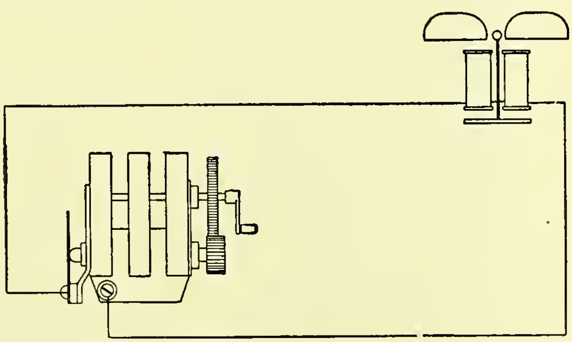


Fig. 748.—Polarized Bell Connected in Circuit with Magneto-generator

Suppose such a bell to be connected in circuit with a magneto-generator as shown in fig. 748. When the generator is operated, powerful currents alternating rapidly in succession are passed through the bell coils, causing the armature to rock on its pivots, and the hammer knob

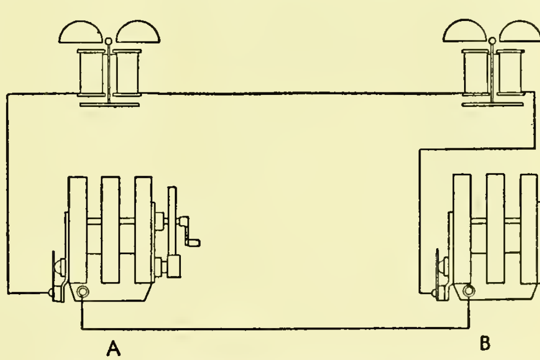


Fig. 749.—Two Bells and Two Generators Connected in Series

to strike rapidly on g and g' with each alternate movement. If two generators and two bells are connected in series, as at A B, fig. 749, signalling can take place between them. This, however, does not make the most of this method of signalling, because both bells and both generators are always in circuit. Thus, when A rings B, the bell at A and the generator armature at B interpose (for the time being) a useless resistance, which reduces the current very considerably. The same may be said when B is ringing to A.

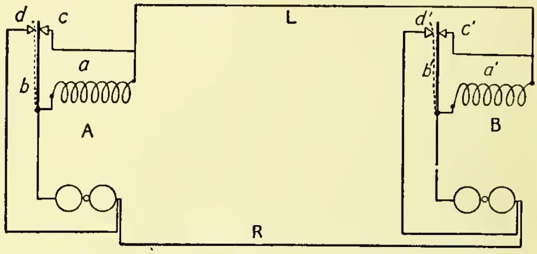


Fig. 750.—Device for Short-circuiting the Armatures and Bells

In telephone practice it is essential that as little current as possible should be wasted, and a device is therefore used which normally leaves the **generator armatures short-circuited,** and, when one station is calling, opens the generator circuit and short-circuits its own bell. This arrangement will be better understood by reference to fig. 750, in which the arrangements are, for the sake of lucidity, shown diagrammatically. a, a' are the armatures of two generators at A and B respectively; b, b' are two flat springs normally resting on contact points c and c'. When the generator handle is turned, a mechanical device causes b to be pressed outwards, breaking contact with c and making contact with d, as shown by broken lines. It will be seen that normally the armatures a, a' are short-circuited by the springs b', and contacts c', and the bells are left in circuit on the line. If a generator is operated, say at A, the spring b, being pressed into contact with d, removes the short circuit from the armature, but short-circuits the bell, thus allowing the full benefit of the current generated to be utilized in ringing the bell at B. Assuming A to be calling up, the circuits may be traced as follows: armature a to line L, contact c' at B, spring b', bell, return wire R, contact d at A, spring b, and armature a. If B is calling: armature a',

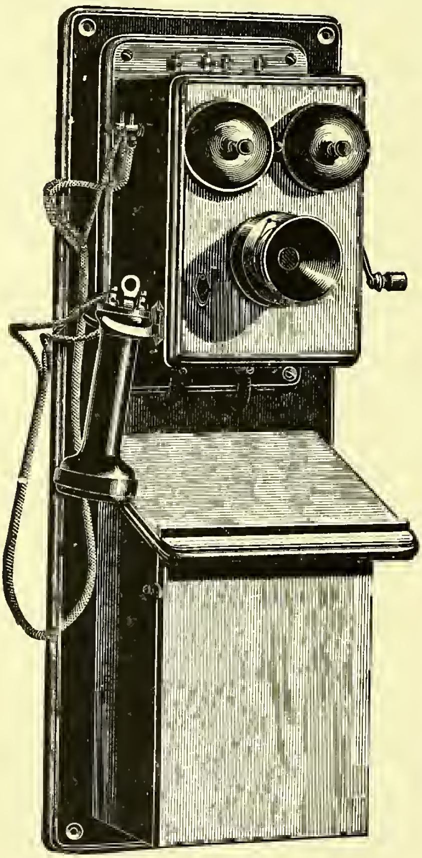


Fig. 751.—Telephone with Magneto-bell, Generator, &c.

line L, contact c at A, spring b, bell, return wire R, contact d', spring b', and armature a'.

Fig. 751 illustrates a standard type of telephone with the magneto-bell, generator, and other component parts of a telephone combined in one piece of apparatus; and fig. 752 shows one method of connecting the various pieces of apparatus with each other. L′, L″ are the line terminals, B is the polarized bell, G the generator, H the switch hook, M the microphone, R the receiver, I the induction coil with primary and secondary windings, M B the microphone battery, r, r', r'', and r''' the receiver terminals, c the calling contact spring, P the primary circuit contact spring, and S the secondary contact spring of switch hook. The calling current, entering the terminal L′, passes to the switch hook H, contact spring c, bell B, generator contact spring a, contact b, to terminal L″, and back to the calling station. On the receiver being lifted from the switch hook, the speaking circuit is as follows: L′ to H, contact spring S, secondary of induction coil, terminal r', receiver, terminal r, and L″. The terminals r'' and r''' are connected in parallel with r and r' for the purpose of connecting an extra receiver if required. The primary circuit is as follows: + of M B, terminal C, switch hook H, contact spring P, primary of induction coil, microphone M, terminal Z, and − of battery.

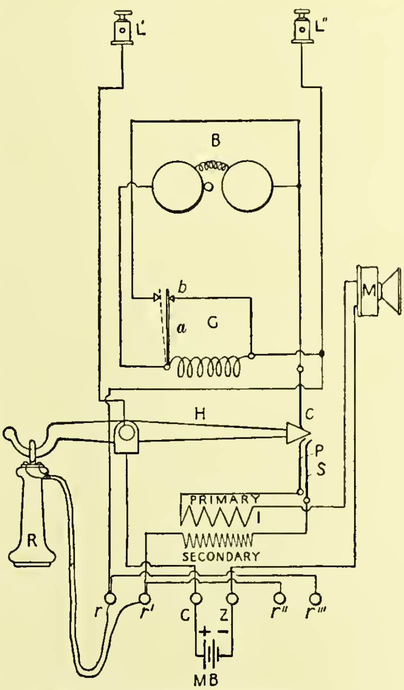


Fig. 752.—A Method of connecting the Parts of the Telephone shown in Fig. 751.